AD

TECHNICAL REPORT

73-17-FL

CONTROLLING THE AMOUNT OF INTERNAL AQUEOUS SOLUTION IN INTERMEDIATE MOISTURE FOODS

by

Robert L. Pavey

Swift & Company

Research and Development Center

Oak Brook, Illinois 60521

Contract No. DAAG 17-70-C-0077

December 1972

UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760

FOOD LABORATORY

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FOREWORD

Intermediate moisture foods offer a number of potential advantages for special military situations. They are concentrated foods which can be eaten without preparation and without the sensation of dryness generally encountered with fully dehydrated products. They are plastic and can be compressed into configurations for maximum packaging and packing efficiency. Their resistance to microbial growth provide an additional margin of safety and wholesomeness even if the integrity of the package is breached, as may occur in air-drop delivery. Previous investigations have shown that a great variety of foods can be easily adjusted to a desired level of water activity by equilibration with an external solution containing a predetermined concentration of glycerol. Such a procedure, however, does not permit control of the amount of glycerol solution remaining in the product. Experience has demonstrated that product acceptability is significantly impaired by the concentration of glycerol normally required to adjust water activity (A_W) to 0.85.

This experimental program seeks to improve the acceptability of representative intermediate moisture foods, particularly meats, by reducing the amount of glycerol per unit of product. Two approaches are to be exploited concurrently. First, the requirement for glycerol is to be decreased by a controlled reduction in the amount of water present. Second, an additional decrease in the requirement for glycerol is anticipated by incorporating sodium chloride at the maximum feasible level which, in itself, will not adversely affect acceptability.

This investigation was performed at the Research and Development Center of Swift & Company, Oak Brook, Illinois 60521, under Contract No. DAAG17-70-C-0077, Project No. 1J662708D553, Food Processing and Preservation Techniques. Dr. Robert L. Pavey served as Principal Investigator under the general supervision of Mr. D. D. Duxbury. Dr. Pavey was assisted by Dr. R. B. Tompkin and Mrs. A. E. Dethmers. Dr. Maxwell C. Brockmann and Mr. Justin M. Tuomy served as Project Officer and Alternate Project Officer, respectively, for the U. S. Army Natick Laboratories.

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ABSTRACT

Glycerol, salt and potassium sorbate were incorporated into 14 cooked food items, specifically diced beef, ground beef, chicken meat (white), pork tenderloin, turkey meat (dark), halibut, ham, sliced carrots, pineapple, peaches, sweet potatoes, omelet, bologna and pancake, in amounts to produce a water activity of 0.83 ± 0.02 after drying to prescribed levels of internal solution approximately 100, 50, 25 and 10% that of a conventionally prepared counterpart. Salt in an amount deemed normal to the specific item and glycerol in the amount needed to adjust water activity were incorporated into the formulas of the last 3 named products; the remaining items were equilibrated by soaking in an external solution containing salt and glycerol. Analytical measurements were performed on all products and appropriate controls for moisture, total and soluble solids, fat, water activity, density and expressable fluid. Intermediate moisture products were stored for 3 months at 38°C and subsequently tested for moisture content, expressable fluid, rancidity, browning, viable microorganisms and acceptability. Observations revealed acceptability as the primary area of difficulty. While most items received an acceptable score at the 100 and 50% drying level, many panel members recognized the off-flavor caused by the presence of glycerol. Drying to the 25 and 10% level generally elicited comments of poor texture and appearance from excessive drying.

INTRODUCTION

The primary objective of this contract was to develop and demonstrate one or more commercially feasible procedures for preparing prescribed acceptable, stable, intermediate moisture foods having specified ratios between the internally held solution (aqueous phase) and the dry food solids.

Specifically the following products were to be developed during phase I of this contract.

(1) Cooked Beef (rib-eye, no trimmable fat or connective tissue)

(2) Cooked Ground Beef (chuck, analytical fat less than 20%)

(3) Cooked White Meat Chicken (no trimmable fat or skin or connective tissue)

(4) Cooked Pork Tenderloin (no trimmable fat or connective tissue)

(5) French Omelet (Boston Cooking School Cookbook)

(6) Cooked Sliced Carrots

(7) Cooked Sliced Pineapple (water pack)

Product portions for processing were to be uniform 1 cm thickness and a minimum volume of 5 cm^3 except for items 2, 5, 6 and 7.

Water activity was to be adjusted within the range of 0.80 to 0.85 at 25°C by the presence of an internal solution containing glycerol, sodium chloride, potassium sorbate (sorbic acid) and appropriate flavoring agents. The term "internal solution" designates the aqueous phase which is bound or otherwise retained by the tissue at 25°C when subjected to a pressure of 2 Kg/cm^2 for 5 minutes. Added sodium chloride was not to result in product which exceeds a normal salt level evaluated by a panel. Potassium sorbate shall not exceed 0.2 percent in the prepared product. All additions were to be food grade as defined by the Food Chemicals Codex.

The products developed were to conform to the following ratios of internal solution to food solids:

(1) Within 20 percent of the moisture solids ratio of the original product,

(2) One-half of (1) above,

(3) One-fourth of (1) above,

(4) One-tenth of (1) above.

Freeze drying was not to be used in achieving the above ratios unless first receiving written permission of the contracting officer.

The following analytical data were to be provided for the representative original products.

(1) Moisture content,

(2) Fat content,

(3) Soluble solids,

(4) Dry solids,

(5) Water activity (A_w),

(6) Density of unit portions.

The following analytical data were to be provided for intermediate moisture products developed in the investigations.

(1) Water activity (A_w),

(2) Density of unit portions,

(3) Fat content,

(4) Internal solution (weight percent),

(5) Moisture (weight percent).

Representative products were to be sealed in water vapor impermeable containers and stored for a period of three months at 38°C. The following data were required after storage.

(1) Viable microorganisms (Standard Plate Count),

(2) Loss of internal solution,

(3) Evidence of physical or chemical deterioration.

The products were to be evaluated for acceptability on a 9-point hedonic scale after storage at 38°C for three months.

During phase II of this contract observations performed under phase I were to be extended for the following food products.

(1) Cooked Dark Meat Chicken or Turkey (no trimmable connective tissue or skin)

(2) Cooked Cod or Halibut Fillets

(3) Canned Ham (no trimmable fat or connective tissue)

(4) Bologna (analytical fat less than 30%)

(5) Pancake or French Toast

(6) Boiled White or Sweet Potato

(7) Canned Peaches or Pears (water pack).

Upon completion of phase II, freshly prepared 500 gram samples of each of the 14 food products at each ratio of internal solution to food solids were submitted to the project officer.

Experimental Approach:

Previous studies in developing intermediate moisture foods found that the use of a "soak-equilibration" procedure where products were cooked and equilibrated in glycerine solutions produced moist satisfactory results.[1] Other methods which were considered worthy of investigation in this study included direct addition of glycerol by formulation or by injection, the incorporation of glycerol before, during or after cooking, the method of cooking as well as methods of concentrating the internal solution to desired intermediate levels within the prepared product.

1) Hollis, F. et al, Parameters for Moisture Content for Stabilization of Food Products (Phase II), U. S. Army Natick Laboratories Tech. Report 70-12-FL.

EXPERIMENTAL PROCEDURES AND RESULTS

I. Evaluation of Cooking Methods

Diced Meat Products:

Methods of cooking meat products included evaluation of: (1) canning and retorting at 6 psi steam pressure to 70°C minimum internal temperature, (2) canning and cooking in 77°C water bath to 70°C minimum temperature, (3) water cooking in an open steam kettle for diced meat until done, and (4) oven roasting in 165°C oven until reaching 70°C internal temperature. In addition, canned product was either cooked as solid pieces or as diced raw meat. Ham was also cooked with glycerol and salt in the can in an attempt to equilibrate the product during cooking and a subsequent holding period. Similarly direct cooking was performed in infusion solutions followed by an equilibration period.

From these studies it was found that oven roasting resulted in surface hardening of the product which was unsuitable for infusion. The surfaces therefore had to be trimmed which was considered to be unsatisfactory.

Retort cooking of canned product with or without added glycerol resulted in a greater product shrink than did water cooking of canned product. This greater shrink was believed to be the reason that these products were more tough or hard after drying than were water cooked canned products. Salt could be added to the product prior to this cooking if desired, however addition of glycerol to the uncooked product was not successful due to poor distribution of glycerol in the product. An apparently long equilibration period was required to obtain equal distribution of the glycerol throughout solid meat tissue when added directly to the product prior to cooking. Dicing of the meat prior to cooking in glycerol in the can resulted in good equilibration but poor dice characteristics due to product shrinkage and particle breakup. This method would have commercial application if particle configuration was not critical.

Direct water cooking of diced raw product in a steam kettle either in water or infusion solutions resulted in extensive irregularity in cooked product dimension and considerable particle breakup resulting in poor appearance of the final product. This method of cooking was found satisfactory for ground meat as is discussed below.

Best results for achieving uniformly controlled internal solutions were found when these products were cooked in cans or casings in a water bath. Therefore, meat to be diced was canned and cooked in a water bath until reaching desired internal temperatures, chilled and diced for equilibration in an external solution.

Ground Meat:

Methods of cooking ground meat (beef) included oven browning, steam kettle or braizier browning, and water cooking with and without glycerol, salts and flavoring materials. Oven browning, steam kettle browning and braizier browning all resulted in hard surfaces of ground particles which did not infuse properly and were very hard after drying. Therefore, water cooking was the only method which was further evaluated. Perhaps cooking of solid meat tissue followed by grinding would be satisfactory, however this was not evaluated in this study. The results achieved by cooking in infusion solution followed by an equilibration period under refrigeration were highly satisfactory and consequently no further studies were conducted for this product. Such prepared products had highly uniform distribution of glycerol and good particle size.

Halibut Fillets:

Frozen halibut was defrosted and cut into 1 cm thick pieces. Various cooking methods and equilibration procedures were investigated. Baking or broiling the fillet resulted in formation of a crust on the product which prevented equilibration in solution and also inhibited drying procedures. Boiling of the fillet resulted in breaking up of the pieces of meat. Steaming of the fillet gave best results in regard to retaining fillet structure, equilibration properties and drying characteristics. It was also found desirable to equilibrate the fillets in solution prior to steam cooking in order to retain particle size of the fillet. The fillets tended to break up during handling if precooked prior to equilibration.

Other Products:

All other products were either precooked as starting materials or were cooked in conventional manners requiring no evaluation of other cooking methods.

II. Method of Product Preparation (Phase I)

Beef Rib-Eye, Cooked, Diced:

Beef rib-eye from U. S. good grade cattle were trimmed of all fat and connective ssssue, cut into approximately 2-inch cubes, vacuum mixed for 8 minutes, stuffed into metal cans, vacuum sealed and water cooked to 70°C internal temperature. After chilling the cans were opened, the product was sliced to 1 cm thickness and then cut into 2.5 x 2.5 cm pieces. A sample of this product was used as control product. The cooked diced meat was then placed in equal parts of 70°C equilibration solution shown in Table I and held overnight in a refrigerated room to equilibrate. After equilibration the product was drained from the solution prior to drying.

Ground Beef, Chuck:

U. S. commercial beef chuck was used for this product. It was ground through a 1/4-inch (6.4 mm) grinder plate, then mixed by hand to provide a more uniform product for all treatments. This ground meat was cooked with equal parts equilibration solution shown in Table I until brown. Control product was cooked in water only. The meat and the solution were then chilled and placed in a refrigerated room overnight. The product and surrounding solution were warmed prior to draining of the excess solution. After draining, the product was spread on drying trays and dried in the same manner as the diced beef rib-eye above.

Chicken White Meat, Cooked:

Chicken white meat was mixed with 1% salt in a vacuum mixer, then canned, cooked and diced in the same manner as the beef rib-eye above. Diced meat was then soaked in the infusion solution shown in Table I under refrigeration overnight, drained and dried in the same manner as the beef rib-eye. Control product was not soaked in a solution.

Pork Tenderloin, Cooked:

This product was treated in identical manner as was the beef rib-eye except that 1% salt was added to the meat prior to mixing and cooking. Infusion in solutions shown in Table I and drying were accomplished identical to the beef rib-eye. Control product was not soaked in solution.

French Omelet:

French Omelets were prepared with glycerol incorporated into the omelet mix and by glycerol infusion by soaking omelets in solutions after cooking with equal success. Since glycerol incorporation into the omelet mix prior to cooking is easier and results in no waste of glycerol as is the case with infusion solutions, this method was used for preparation of omelets. Formulations for these treatments are shown in Table III. The omelets were cooked in Teflon coated omelet skillets over a gas range until starting to set and then under a broiler until done. The cooked omelets were then dried as discussed below.

Carrots, Sliced, Cooked:

Carrots have been cooked with glycerol in the cook water and without glycerol in the cook water followed by a soak infusion in glycerol solutions after draining (see Table I). Both have been found to be equally successful and the use of glycerol in the cook water was used due to more carrot flavor being retained. After cooking, the carrots in solution were chilled and held overnight under refrigeration to achieve equilibration. After equilibration the carrots were drained of excess solution and dried. Control carrots were cooked in water and drained immediately for analysis.

Pineapple, Sliced, Water Packed, Drained:

Sliced pineapple canned in its own juices was drained and then soaked in infusion solutions overnight. Control pineapple sample was taken after draining and prior to soaking. It was found that using pineapple juice rather than water in the infusion solutions greatly improved the pineapple flavor. Due to the high sugar content of this juice, less glycerol was required in infusion solutions (see Table I). In the 10% internal solution product it was found that no glycerol was required to achieve proper water activity. The infused pineapple was drained and dried.

III. Method of Product Preparation (Phase II)

Turkey Dark Meat:

Boneless raw turkey dark meat was ground through a 4-inch (10.26 cm) grinder having a 3-hole tear drop plate and knife. The ground meat was then vacuum mixed until achieving a tacky surface to all pieces. One percent salt was added and mixed with this product. The

mixed turkey was then stuffed into casings and cooked in a 83°C water bath until reaching 77°C internal temperature. The product was then chilled in running cold water and refrigerated at -3° to 0°C until used.

The cooked turkey was removed from the casing and diced into 1 x 2.5 x 2.5 cm pieces and soaked in equal parts of equilibration solution as shown in Table II overnight under refrigeration. Control samples were taken prior to soaking. Best results were achieved when the solution was heated to 83°C prior to the addition of the turkey meat and allowed to cool under refrigeration during the equilibration period. After equilibration the product was drained from the solution prior to drying.

Halibut Fillets:

Frozen halibut was defrosted and cut into 1 cm thick pieces. The sliced raw halibut was equilibrated in the solutions shown in Table II overnight under refrigeration. The equilibrated product was drained, placed on drying trays, basted with butter or margarine, sprinkled with paprika and steamed until done. After steaming the free juices were drained off and the product was dried. Control halibut was handled in the same manner except it was not soaked in equilibration solutions.

Canned Ham:

Commercial cooked canned sectioned and formed ham was cut into 1 x 2.5 x 2.5 cm cubes and equilibrated in equal parts equilibration solutions shown in Table II. Control products were not soaked in solution. This equilibration was conducted overnight under refrigeration. After equilibration the product was drained and dried.

Bologna:

It was found that glycerol could be added to bologna formulations during chopping without affecting binding properties of the product. Water was reduced or eliminated from the formulation with additions of glycerol. Other changes were also made in the formulas to adjust flavors of the products. It was found that spice levels had to be increased with increasing levels of glycerol. The dextrose was removed to prevent excess sweetness and browning problems when glycerol was added.

The bologna formulas are shown in Table IV. Treatment 4 product was used also as control product. These were prepared in an identical manner of preparing and processing commercial bologna. The final prepared bologna was then sliced and dried to desired moisture levels.

Pancake:

Both complete pancake mix and regular or "original" pancake mixes which require addition of milk, eggs and shortening were studied. It was found that the complete mix was satisfactory and the simplest to control. Therefore, this was used in preparing the pancake products. Formulations for these products are shown in Table V. Treatment 4 pancakes were used for control product. These formulations were simply mixed, grilled in the normal manner on a gas-fired grill until cooked throughout and dried to the desired moisture levels.

Sweet Potatoes:

Commercial canned whole sweet potatoes in syrup were drained and sliced longitudinally to 1 cm thickness. Samples of sliced sweet potato were used as control product. The sliced sweet potatoes were then equilibrated in equal parts equilibration solution as shown in Table II. After equilibrating under refrigeration overnight the product was drained and dried to the desired moisture levels.

Canned Spiced Peaches:

Both peaches and pears were initially evaluated and it was found that the flavor of glycerol was not compatible with that of pears. Both sliced and halved peaches were evaluated and it was found that halved peaches took much longer to equilibrate and also did not dry uniformly. Therefore, sliced peaches packed in natural juices were used. These were drained and then equilibrated in equal parts of aqueous solution shown in Table II. Control peaches were taken from the drained product prior to equilibration. After equilibrating overnight under refrigeration the peaches were drained and dried to the desired moisture levels.

TABLE I

Infusion Solutions (Phase I)

Product Equilibration Solution Composition[2]	Treatment[1] 1 %	2 %	3 %	4 %
Beef Rib-Eye, Cooked				
Water	60.6	74.67	87.25	97.8
Glycerol, 99% CP	24.0	15.00	7.50	-
Soup & Gravy Base, Beef (Griffith)	15.0	10.00	5.00	2.0
Potassium Sorbate	0.4	0.33	0.25	0.2
Ground Beef, Cooked				
Water	63.6	77.67	88.75	97.8
Glycerol, 99% CP	21.0	12.00	6.00	-
Soup & Gravy Base, Beef	15.0	10.00	5.00	2.0
Potassium Sorbate	0.4	0.33	0.25	0.2
Chicken White Meat, Cooked				
Water	49.6	67.17	83.25	94.3
Glycerol, 99% CP	30.0	20.00	10.00	3.0
Soup & Gravy Base, Chicken	20.0	12.50	6.50	2.5
Potassium Sorbate	0.4	0.33	0.25	0.2
Pork Tenderloin, Cooked				
Water	58.1	72.17	85.75	97.3
Glycerol, 99% CP	24.0	15.00	7.50	-
Soup & Gravy Base, Beef	7.5	5.00	2.50	1.0
Soup & Gravy Base, Chicken	10.0	7.50	4.00	1.5
Potassium Sorbate	0.4	0.33	0.25	0.2
Carrots, Sliced, Cooked				
Water	50.4	69.5	84.70	93.9
Glycerol, 99% CP	45.0	27.5	13.75	5.5
Salt	4.3	2.8	1.40	0.5
Potassium Sorbate	0.3	0.2	0.15	0.1
Pineapple, Sliced, Drained				
Pineapple Juice[3]	51.7	74.8	87.35	99.9
Glycerol, 99% CP	48.0	25.0	12.50	-
Potassium Sorbate	0.3	0.2	0.15	0.1

1) Treatment 1 = ± 20% of original solution/solids.
2 = 50% of Treatment 1.
3 = 25% of Treatment 1.
4 = 10% of Treatment 1.

2) Equal parts solution to product by weight.

3) 85.0% water by analysis.

TABLE II

Infusion Solutions (Phase II)

Product Equilibration Solution Composition[2]	Treatment[1] 1 %	2 %	3 %	4 %
Turkey, Dark Meat, Cooked				
Water	48.1	66.17	83.25	93.3
Glycerol	35.0	22.50	10.00	3.0
Soup & Gravy Base, Chicken	15.0	10.00	6.50	3.5
Salt	1.5	1.00	.00	.0
Potassium Sorbate	.4	0.33	0.25	0.2
	100.0	100.00	100.00	100.0
Halibut Fillet, Raw				
Water	47.7	71.8	84.34	95.4
Glycerol	35.0	18.0	9.00	.0
Lemon Juice[3]	10.0	6.0	4.00	3.0
Salt	7.0	4.0	2.50	1.5
Potassium Sorbate	0.3	0.2	0.15	0.1
	100.0	100.0	100.00	100.0
Ham, Cooked, Diced				
Water	60.0	80.0	89.5	98.8
Glycerol	30.9	15.1	7.7	.0
Salt	8.5	4.5	2.5	1.0
Potassium Sorbate	0.3	0.2	0.15	0.1
Liquid Smoke, C-6 Charsol	0.3	0.2	0.15	0.1
	100.0	100.0	100.00	100.0
Sweet Potato, Drained				
Juice[4]	54.0	72.0	85.85	99.9
Glycerol	45.7	27.8	14.00	.0
Potassium Sorbate	0.3	0.2	0.15	0.1
	100.0	100.0	100.00	100.0
Peaches, Drained				
Juice[5]	54.0	77.3	89.85	98.9
Glycerol	45.7	22.5	10.00	1.0
Potassium Sorbate	0.3	0.2	0.15	0.1
	100.0	100.0	100.00	100.0

1) Treatment 1 = 100 $\pm$ 20% of original solution/solids
2 = 50% of treatment 1
3 = 25% of treatment 1
4 = 10% of treatment 1

2) Equal parts solution to product by weight.

3) 91% water (USDA Handbook No. VIII)

4) 74.8% water by analysis.

5) 86.2% water by analysis.

TABLE III

French Omelet Formulation

	Treatment[1] 1 %	2 %	3 %	4 %
Egg	65.375	71.4946	75.4943	78.6541
Water	16.0	17.4	18.5	19.25
Salt	.82	.9	.95	.99
Pepper	.005	.0054	.0057	.0059
Glycerol	17.5	10.0	5.0	1.0
Potassium Sorbate	.300	.20	.15	.1
	100.0000	100.0000	100.0000	100.0000

1) Treatment 1 = 100 ± 20% of original solution/solids
2 = 50% of Treatment 1
3 = 25% of Treatment 1
4 = 10% of Treatment 1

TABLE IV

Bologna Formulation

	Treatment[1] 1 %	2 %	3 %	4 %
Meat	79.500	79.500	79.500	79.500
Water (Ice)	.000	8.104	12.824	13.724
Glycerol	14.364	7.260	2.330	.000
Salt	4.000	3.200	2.800	2.400
Dextrose	.000	.000	.000	1.200
Corn Syrup Solids	.000	.000	.800	1.600
Processed Mustard	.800	.800	.800	.800
Cure "A" (Swift)	.105	.105	.105	.105
Sodium Erythorbate	.035	.035	.035	.035
Bologna Seasoning (Swift)	.820	.670	.530	.410
Garlic Powder	.006	.006	.006	.006
Liquid Smoke (C-6 Charsol)	.070	.070	.070	.070
Potassium Sorbate	.300	.250	.200	.150
	100.00	100.000	100.000	100.000

1) Treatment 1 = 100% ± 20% of original solution/solids.
2 = 50% of treatment 1.
3 = 25% of treatment 1.
4 = 10% of treatment 1.

TABLE V

Pancake Formulation

	Treatment[1]			
	1	2	3	4
	%	%	%	%
Pancake Mix[2]	50.0	50.0	50.0	50.0
Water	37.2	42.3	44.85	49.9
Glycerol	12.5	7.5	5.0	.0
Potassium Sorbate	0.3	.2	.15	.1
	100.0	100.0	100.00	100.0

1) Treatment 1 = 100% ± 20% of original solution/solids.
2 = 50% of treatment 1.
3 = 25% of treatment 1.
4 = 10% of treatment 1.

2) Pancake mix used was Aunt Jemima Complete Pancake Mix.

IV. Method of Adjusting Internal Solution Water Activity (A_w)

Methods evaluated for glycerol and other additives included infusion prior to cooking, infusion during cooking and infusion after cooking. Methods of infusion were soaking in solutions before or after cooking, direct glycerol additions during cooking with subsequent equilibration, and injection of glycerol solutions directly into raw or cooked product.

Injection of glycerol or glycerol solutions directly into raw or cooked products resulted in a poor distribution of the solutions as evidenced by pocketing of the glycerol and by uneven weight gains. Attempts to pump green hams with a pickle solution containing glycerol both by needle injection and by artery pumping followed by holding under a cover pickle containing glycerol for up to three days were all found unsatisfactory for achieving control of the internal solution. After the above treatments the hams were separated by muscle, canned and cooked. The artery pumped hams had greater weight gains, higher levels of glycerol and lower water activities than those needle pumped. In addition, the knuckle muscles had the highest levels of glycerol, being over twice that of the outside muscles. Variations between treatments and muscles were found to range from 6.9% to 20.8% glycerol. Salt was also found to vary from 1.0% to 3.6%, being closely associated with corresponding glycerol levels. Due to these variations, this method of producing products with controlled internal solutions was abandoned.

Direct addition of glycerol to product formulations worked very well for French omelet, pancake, bologna and for canned meat dices during cooking, but not for non-diced meats. This method was found to be the simplest for formulated products and was used for such products.

Soak infusion during or after cooking has been very successful for all cooked product and for raw halibut fillets. Soak infusion during cooking with subsequent equilibration overnight under refrigeration was found most successful for ground beef and carrots. Soak infusion after cooking and dicing was found most successful for diced meats, sliced pineapple, peaches and sweet potatoes. Time of soaking to achieve proper equilibration was investigated at 2, 4, 8 and 16 hours. Most uniform results were observed after 16 hours (overnight) under refrigeration and was, therefore, used throughout this study.

V. Method of Determining Equilibration Solution Compositions

It was determined that equal parts of solution to product was sufficient to adequately cover products for cooking and/or equilibration purposes. Therefore, all equilibration solutions were based on an equal part basis for all products requiring equilibration. Initial product moistures were determined in order to determine the concentration of solution required for equilibration. Initial water activity (A_w) was also determined. Calculations were made to determine the concentrations of salt and glycerol required to equilibrate to an A_w of .85 for the total solution (equilibration solution + product water). In initial calculations it was assumed that salt would tie up 4 times its weight of water and glycerol an equal weight of water. Salt was used at the normally acceptable levels and glycerol was used at the normally acceptable levels and glycerol was used to make the final adjustments for water activity. Initial results using this method showed that such equilibrated products were extremely sweet due to glycerol and lacked saltiness. It was also found that the water activity was lower than anticipated. Therefore, increased salt levels through use of flavoring agents such as soup and gravy base were used to mask the sweetness of these products. It was also found necessary to reduce the amount of water to be equilibrated in order to reduce the sweetness resulting from glycerol. A 10% reduction in moisture resulted in approximately a 14% reduction in the amount of glycerol required. Application of this observation produced a much more acceptable product.

Equilibration solutions for products destined for lower levels of internal aqueous solutions were calculated as a percentage of the highest level and adjusted as required based on water activity and acceptability of these products. Resulting equilibration solutions are shown in Tables I and II.

VI. Method of Preparing Formulated Products

Formulated products were prepared by direct addition of glycerol and flavoring agents, mainly salt, into the product composition. The initial additions were based on calculations of initial product moisture values. These levels were adjusted in order to achieve the proper water activity and internal solution levels and final formulas are shown in Tables III, IV and V for French omelet, bologna and pancake, respectively.

VII. Method of Concentrating to Intermediate Moisture Levels

Methods evaluated were oven drying, vacuum drying, heat evaporation and compression. Oven drying and heat evaporation in a steam kettle at atmospheric pressure both resulted in surface hardening and very tough products even at high intermediate moisture levels (50% of original solution). The use of compression to squeeze out internal solutions to intermediate moisture levels resulted in poor control of end product solution levels. This was more pronounced where a high degree of product variability was present.

Due to the increased toughness of products dried to the lower two levels of internal solution, it was felt that other methods of internal solution adjustment should be investigated. Since fat is readily expressed from bacon and a few other products by compression, this technique seemed a likely method of achieving the lower levels of internal solutions desired. Products previously adjusted to an internal solution for the 80% level were used for this test since it was believed that the solution would be expressed uniformly and remain at the proper water activity. It was found that by controlling the degree of compression volumetrically and by adjusting the amount of original product being compressed, fairly accurate control of the amount of solution being expressed could be obtained at internal solution levels of 40% of the original solution or higher. When attempting to obtain lower levels than the 40% of the original solution, product as well as solution was also being expressed from the orifices in the die. In addition, the resulting products were found to be tough and fibrous or woody. For this reason it was felt that the vacuum drying procedure was equal or superior to the compression procedure and this technique was not further pursued.

Vacuum drying resulted in achieving the most desired intermediate moisture levels and resulting product. This was achieved by using a shelf dryer with heated platens. Vacuum in the drying chamber was controlled to a pressure just above the freezing point of the product, usually 3 mm absolute pressure. Heat was applied during drying as radiant heat from the platens with the product trays being suspended above the heated platens. Temperatures of the platens

evaluted have been from room temperature (25°C) up to 65°C. It was found that temperatures below 38°C were required to prevent case hardening and severe toughening of products dried to the lower internal solution levels. Even with reduced temperatures many products dried to 10% of the original internal solution levels were found to be tough or hard.

In order to improve the texture of low level internal solution products, the platen temperatures were reduced to ambient conditions (25°C) for all products. This resulted in less case hardening of the products during drying. The initial vacuum pressure during drying was 3.0 mm Hg absolute pressure which resulted in product temperatures of approximately -5° to -3°C during initial drying. Due to salt and glycerol concentrations in the products, it was found that the products did not freeze at this temperature. As drying progressed, resulting in higher concentrations of glycerol and salt, the vacuum pressure was reduced to 2.0 mm Hg absolute pressure after 2 hours drying time for products with lower levels of internal solution. This lower pressure did not show evidence of apparent freezing of these products. This procedure of drying resulted in products with less hardening or toughness than had occurred when products were dried at 4.0 mm Hg absolute pressure. This improved the texture of products dried to the lower two levels of internal solution only. Products having higher levels of internal solution were dried to desired levels prior to the reduction in chamber pressures of 2.0 mm Hg absolute.

The drying time for various products were approximately 1 hour for 80% of the original solution levels, 2 hours for 50% solution levels, 3-1/2 to 4 hours for 25% solution levels and 5 to 6 hours for 10% solution levels. Drying pressures used were 3.0 mm Hg absolute for the first 2 hours and 2.0 mm Hg absolute for the remaining drying time. Chamber pressures were regulated by bleeding nitrogen into the product chamber of a freeze dryer during drying. Drying temperature was maintained by circulating a fluid at ambient temperature through the drying shelves. Products were suspended above the shelves, thus heating occurred by radiation. Although this method is slower than using conduction heat, it was felt that more uniform heating would result from use of radiant heat and achieve more uniform drying. Infusion and drying data are shown in Tables VI and VII.

TABLE VI

Infusion and Drying Product Yields - Phase I

	Treatment[1] 1 %	2 %	3 %	4 %
Beef Rib-Eye				
Infused Weight, Drained	117.5	109.4	104.7	103.4
Dried Weight	84.7	61.7	51.8	40.3
Ground Beef				
Infused Weight, Drained	115.6	112.1	109.6	108.0
Dried Weight	85.1	62.9	48.8	43.9
Chicken White Meat				
Infused Weight, Drained	110.7	108.4	106.9	104.1
Dried Weight	85.9	63.5	51.2	36.5
Pork Tenderloin				
Infused Weight, Drained	113.6	112.2	107.7	104.0
Dried Weight	86.9	63.5	47.2	40.8
French Omelet				
Cooked Weight	100.0	100.0	100.0	100.0
Dried Weight	85.7	62.2	47.8	39.0
Carrots				
Infused Weight, Drained	107.0	102.6	100.7	97.1
Dried Weight	84.6	58.9	31.0	19.1
Pineapple				
Infused Weight, Drained	118.7	117.5	108.7	107.0
Dried Weight	91.2	61.6	40.0	24.1

1) Treatments as shown in previous tables.

TABLE VII

Infusion and/or Drying Data - Phase II

	Treatment[1]			
	1	2	3	4
	%	%	%	%
Turkey, Cooked				
Infused Drained Weight	106.9	106.2	104.0	103.8
Dried Weight	88.5	67.7	50.0	39.6
Halibut Fillet				
Infused Drained Weight	124.0	131.7	125.7	110.6
Basted Weight*	134.0	141.7	135.7	120.6
Cooked, Drained Weight	100.8	107.8	100.9	97.5
Dried Weight	83.8	60.5	41.1	29.3
*Basted with butter equal to 10% of original weight.				
Ham, Cooked				
Infused Drained Weight	100.8	102.1	103.4	103.7
Dried Weight	88.7	67.0	50.2	37.8
Bologna				
Cooked Weight	94.6	93.4	92.0	90.7
Dried Weight	87.5	71.1	58.4	49.9
% of Cooked Weight	92.0	75.9	63.4	55.0
Pancake				
Cooked Weight	86.2	90.0	89.1	88.1
Dried Weight	86.2	73.8	62.6	51.8
% of Cooked Weight	100.0	82.2	70.3	58.8
Sweet Potato, Drained				
Infused Drained Weight	103.2	104.1	103.0	100.0
Dried Weight	87.5	62.7	48.3	37.7
Peaches, Sliced, Drained				
Infused Drained Weight	115.0	110.8	112.4	112.3
Dried Weight	83.0	60.3	35.2	22.2

1) Treatments as shown in previous tables.

VIII. Packaging for Storage Evaluation

Products were all packaged in metal cans and either sealed under full vacuum or under partial vacuum and nitrogen flush resulting in an inert atmosphere. These packaged products were refrigerated at 0°C ± 1°C until placed in the 38°C incubator for evaluation after three months storage.

IX. Analytical Methods Used

Analytical and calculated data are shown in Tables VIII and IX. Analytical methods used for these data are as follows:

a. Moisture: Moisture was determined on all products using a 70°C vacuum oven having a pressure of not more than 50 millimeters mercury absolute for a period of 16 hours. Samples were ground and a 2 gram aliquot was used for moisture determination. Drying dishes were covered and allowed to cool to room temperature in a desiccator prior to weighing the dried sample.

b. Fat: Fat was determined by using standard AOAC ether extraction procedures.

c. Soluble Solids: Ground and dried sample was soaked in 200 parts distilled water, held at 45°C in a water bath for 2 hours. The product was then vacuum filtered through filter paper and the process repeated until no further soluble material was removed as determined by no further weight loss in the residue after drying. Water soluble solids were then calculated as total dry solids less dry insoluble residue.

d. Water Activity (A_w): Water activity was determined using equilibrium relative humidity measured by electric hygrometer. Fifty to 100-gram samples were placed in pint glass jars equipped with hygrometer elements in the lid. Determinations were conducted at ambient temperature. Readings were taken from standard curves provided and calibrated for the respective elements used. Temperature was corrected to 25°C from the standard curves by plotting the instrument reading on the temperature curve. Elements used were sensitive to ± 1.5% accuracy.

e. Product Density: Product density was determined by weighing unit portions of the product and determining volume either by physical measurement or by liquid displacement. Liquid displacement was used for all products not having a porous structure. The liquid used was mineral oil at ambient temperature in a graduate cylinder. Products having high density were read directly by difference. Samples which floated were submerged with a glass rod being careful not to extend the rod tip below the surface of the liquid and the readings were made immediately in order to minimize oil absorption into the product.

For products having a porous structure, the product was trimmed to equal lengths, widths and thicknesses to avoid irregular shapes. The volume was calculated from the resulting length, width and thickness dimensions and the product was weighed in order to calculate density.

f. Internal Solution: Internal solution as defined under this contract as the aqueous phase retained at 25°C under a pressure of 2 kilograms per square centimeter for 5 minutes could not be used since many products could not achieve the required levels on internal solution by this definition. As a rational expedient, the weight of internal solution in all intermediate moisture products and corresponding controls (at "normal" A_w) can be closely approximated from the difference between the weight of the product and the weight of the dry solids present in its respective control, since each type of intermediate moisture product and its control represent the same weight of initial material. In converting the weight of internal solution to a percentage of the intermediate moisture product, a yield factor (see % dried weight or, for bologna and pancake, % of cooked weight, Tables VII and VIII) is introduced. Thus, % internal solution =

$$\frac{\text{(wt. product)} - \text{(wt. dry solids in control)}}{\text{wt. product}} \times 100$$

or

$$\frac{\text{\% yield} - \text{\% dry solids in control}}{\text{\% yield}} \times 100$$

All control items have a yield of 100%, thus % internal solution for control = 100 - % dry solids in control.

g. Browning: Browning was determined by using the spectrophotometric fluorescence method using quinine sulfate as a reference solution in a Beckman DK-2A spectrophotometer with a fluorescence attachment and reported as a percent fluorescence per gram.

h. Thio-Barbaturic Acid (TBA): Thio-barbaturic acid (TBA) was determined using the standard AOAC method for fat and oils.

i. Microbial Procedures: Microbial determinations were for standard total aerobic plate counts.

X. Analytical Results

Analytical data and results derived therefrom are presented in Tables VIII and IX for all intermediate moisture products and their respective controls. Data reported for moisture, fat, soluble solids, water activity and density are based on laboratory observations performed as previously described. Percentages are based on end-items identified with the yield data presented in Tables VI and VII.

Total dry solids = 100 - observed percent moisture.

The calculations of percent internal solution have been previously described.

In certain instances (Treatment 4 for beef rib-eye, ground beef, chicken, pork tenderloin, turkey, and ham) this method of measuring internal solution results in a value less than the moisture content of the same product. This difference is explained as a loss of soluble solids during the equilibration treatment. This is due to the fact that in calculating the percent internal solution no consideration of original soluble solids in the control product is made. Any loss of soluble solids during equilibration is, therefore, reflected in the treated products. This was especially the case for pineapple, sweet potatoes and peaches which contain a high level of water soluble solids. For this reason, it was found desirable to equilibrate these products in

order to maintain the original water soluble solids of these products during equilibration since these juices are already in equilibrium with these products. This utilizes the water binding properties of the natural soluble solids as well as maintains a higher level of the natural flavors in these products. This resulted in higher levels of internal solution than the moisture content for these products. In the case of meat products this was not able to be accomplished and lower values did occur.

The ratio, internal solution to total solids is calculated as the weight of internal solution in each product divided by the total solids content (or percentage) recorded for the respective control. As an alternative calculation, this ratio =

$$\frac{\% \text{ internal solution}}{100 - \% \text{ internal solution}}$$

In calculating the above ratio of internal solution to total solids as a fraction of the corresponding ratio of the control, the ratio as calculated above is divided by the ratio as calculated for the respective control.

Data of Tables VIII and IX reveal that, with minor exceptions, intermediate moisture products fall within the prescribed range of water activity and, based on the calculations used, generally adhere to the required levels of internal solution with respect to their basic solids content. It should be recognized that inclusion of soluble solids with the total solids has a marked effect on the values calculated for the ratio of internal solution to solids. However, the effect of such soluble solids is eliminated when the ratio of internal solution to solids is calculated relative to the control.

A further source of potential error in the ratios reported in Tables VIII and IX items from the possibility that the presence of glycerol and salt may have increased the solubility of a component of the intermediate moisture product relative to its solubility in the control. Also, no correction has been made for the fat content of the products. In view of the analytical procedures it is probable that the fat is included in the soluble fraction. These possibilities together with

TABLE VIII

Analytical Data - Phase I

Product Treatment	Moisture %	Fat %	Dry Solids %	Soluble Solids %	Internal Solution %	Internal Solution Ratio[1)]	Internal Solution % of Control[2)]	A_w ERH	Density g/cc
Beef Rib-Eye									
Control	63.1	5.4	36.9	5.7	63.1	1.71	1.00	.99	1.116
Tr. 1	44.4	5.4	55.6	20.5	56.4	1.29	0.75	.86	1.113
Tr. 2	32.3	9.3	67.7	18.2	40.2	0.67	0.39	.82	1.107
Tr. 3	22.9	12.8	77.1	18.3	29.0	0.41	0.23	.83	1.085
Tr. 4	18.9	16.2	81.1	10.2	8.4	0.09	0.05	.83	1.070
Beef, Ground									
Control	62.2	15.7	37.8	4.8	62.2	1.65	1.00	.99	1.039
Tr. 1	45.1	12.6	54.9	28.3	55.6	1.25	0.76	.85	1.034
Tr. 2	33.3	16.3	66.7	25.8	39.9	0.66	0.40	.80	1.016
Tr. 3	24.6	22.4	75.4	19.2	22.5	0.29	0.18	.77	0.994
Tr. 4	19.4	25.6	80.6	12.3	13.9	0.16	0.10	.82	0.983
Chicken, White Meat									
Control	70.7	1.5	29.3	6.2	70.2	2.41	1.00	.99	1.094
Tr. 1	46.4	2.1	53.6	26.2	65.9	1.93	0.80	.84	1.129
Tr. 2	41.2	2.4	58.8	25.5	53.9	1.17	0.49	.83	1.125
Tr. 3	31.8	3.4	68.2	25.2	42.8	0.75	0.31	.82	1.112
Tr. 4	28.5	3.7	71.5	16.4	19.7	0.25	0.10	.86	0.922
Pork Tenderloin									
Control	67.8	3.4	32.2	5.8	67.8	2.11	1.00	.99	1.099
Tr. 1	47.0	4.9	53.0	27.5	62.9	1.70	0.80	.84	1.123
Tr. 2	37.2	5.8	60.8	23.1	49.3	0.97	0.46	.83	1.118
Tr. 3	29.7	7.0	70.3	24.8	31.8	0.47	0.22	.83	1.102
Tr. 4	24.8	8.4	75.2	12.9	21.1	0.27	0.13	.83	1.021

TABLE VIII
(Continued)

Analytical Data - Phase I

Product Treatment	Moisture %	Fat %	Dry Solids %	Soluble Solids %	Internal Solution %	Internal Solution Ratio[1]	Internal Solution % of Control[2]	A_w ERH	Density g/cc
French Omelet									
Control	71.6	13.2	28.4	0.0	71.6	2.52	1.00	.98	1.120
Tr. 1	48.8	12.9	51.2	28.7	66.9	2.02	0.80	.83	1.103
Tr. 2	44.2	19.1	55.8	28.2	54.3	1.19	0.47	.84	1.081
Tr. 3	33.7	26.2	66.3	28.6	40.6	0.68	0.27	.83	0.927
Tr. 4	24.1	32.7	75.9	23.0	27.2	0.37	0.15	.80	0.902
Carrots, Sliced									
Control	90.1	-	9.9	6.3	90.1	9.1	1.00	.98	1.030
Tr. 1	52.4	-	47.6	41.7	88.3	7.55	0.83	.85	1.154
Tr. 2	50.6	-	49.4	39.6	83.2	4.95	0.54	.83	1.129
Tr. 3	45.5	-	54.5	44.2	68.1	2.13	0.23	.83	1.200
Tr. 4	36.6	-	63.4	40.3	48.2	0.93	0.10	.82	0.925
Pineapple, Sliced									
Control	84.4	-	15.6	14.4	84.4	5.41	1.00	.98	1.064
Tr. 1	54.5	-	45.5	43.2	82.9	4.85	0.90	.84	1.147
Tr. 2	48.9	-	51.1	47.6	74.7	2.95	0.55	.81	1.181
Tr. 3	36.2	-	63.8	52.9	61.0	1.56	0.29	.80	1.208
Tr. 4	35.7	-	64.3	57.7	35.3	0.55	0.10	.78	1.188

1) Ratio of internal solution to dry solids = $\frac{\% \text{ Internal Solution}}{100 - \% \text{ Internal Solution}}$

2) Treatment ratio/control ratio.

TABLE IX

Analytical Data - Phase II

Product Treatment	Moisture %	Fat %	Dry Solids %	Soluble Solids %	Internal Solution %	Internal Solution Ratio[1]	Internal Solution % of Control[2]	A_w ERH	Density g/cc
Turkey									
Control	67.7	3.8	32.3	5.1	67.7	2.09	1.00	.99	1.11
Tr. 1	46.4	4.7	53.6	34.2	63.4	1.73	0.83	.85	1.13
Tr. 2	40.1	6.9	59.9	31.2	52.3	1.10	0.52	.84	1.12
Tr. 3	30.8	9.3	69.2	24.5	35.4	0.55	0.27	.83	1.07
Tr. 4	23.8	11.9	76.2	17.0	18.4	0.23	0.11	.84	0.92
Halibut									
Control	79.5	1.4	20.5	3.7	79.5	3.88	1.00	.97	1.07
Tr. 1	54.3	1.8	45.7	22.0	75.5	3.08	0.79	.84	1.09
Tr. 2	52.9	2.3	47.1	19.4	66.1	1.95	0.52	.83	1.05
Tr. 3	42.0	3.3	58.0	16.2	50.1	1.00	0.26	.84	0.98
Tr. 4	29.3	5.3	70.7	10.4	30.0	0.43	0.11	.82	0.82
Ham									
Control	70.1	4.3	29.9	11.8	70.1	2.34	1.00	.97	1.12
Tr. 1	52.1	4.8	47.9	24.6	66.4	1.98	0.84	.82	1.13
Tr. 2	48.2	5.4	51.8	22.0	55.3	1.24	0.53	.83	1.13
Tr. 3	41.0	7.2	59.0	20.7	40.4	0.68	0.29	.83	1.09
Tr. 4	35.5	8.9	64.5	16.3	20.9	0.26	0.11	.82	0.98
Bologna									
Control	51.7	24.7	48.3	5.8	51.7	1.07	1.00	.94	1.09
Tr. 1	34.2	26.4	58.0	36.6	47.5	0.90	0.84	.85	1.11
Tr. 2	30.2	33.2	63.8	32.1	36.4	0.57	0.53	.83	1.07
Tr. 3	20.4	38.5	69.4	28.3	23.8	0.31	0.29	.85	1.03
Tr. 4	10.6	46.8	83.4	11.2	12.2	0.14	0.13	.70	0.94

TABLE IX
(Continued)

Analytical Data - Phase II

Product Treatment	Moisture %	Fat %	Dry Solids %	Soluble Solids %	Internal Solution %	Internal Solution Ratio[1]	Internal Solution % of Control[2]	A_w ERH	Density g/cc
Pancake									
Control	47.1	3.1	52.9	13.8	47.1	0.89	1.00	.96	0.90
Tr. 1	31.6	3.2	63.7	28.3	47.1	0.89	1.00	.84	0.84
Tr. 2	27.1	4.2	72.9	26.3	35.6	0.55	0.62	.81	0.80
Tr. 3	18.5	5.3	81.5	23.6	24.8	0.33	0.37	.72	0.68
Tr. 4	10.1	6.4	89.9	22.0	10.0	0.11	0.12	.60	0.58
Sweet Potato									
Control	71.8	-	28.2	20.8	71.8	2.55	1.00	.98	1.08
Tr. 1	52.0	-	48.0	37.9	67.8	2.11	0.83	.83	1.10
Tr. 2	42.2	-	57.8	43.4	55.0	1.22	0.48	.81	1.09
Tr. 3	36.9	-	63.1	41.1	41.6	0.71	0.28	.82	1.03
Tr. 4	24.1	-	75.9	47.4	25.2	0.34	0.13	.80	0.98
Peaches									
Control	86.2	-	13.8	13.3	86.2	6.25	1.00	.96	1.05
Tr. 1	60.9	-	38.1	34.4	83.4	5.02	0.80	.84	1.08
Tr. 2	58.4	-	41.6	36.3	77.1	3.37	0.54	.83	1.03
Tr. 3	37.1	-	60.9	41.7	60.8	1.55	0.25	.81	0.99
Tr. 4	27.7	-	72.3	40.9	37.8	0.61	0.10	.81	0.97

1) Ratio of internal solution to dry solids = $\frac{\% \text{ Internal Solution}}{100 - \% \text{ Internal Solution}}$

2) Treatment ratio/control ratio.

other relevant observations are developed in the further analyses of data contained in Tables X through XXIII.

The notes to follow are intended to clarify the calculations underlying Tables X through XXIII. While it is deemed unnecessary to identify the assumptions implicit in each calculation for all intermediate moisture products prepared by soaking the aqueous phase and all components soluble therein are assumed to be fully equilibrated between the food and solution external thereto. In addition, in subsequent drying operations only water is assumed to be lost.

Lines 1-5. Data are from laboratory observations or are derived immediately therefrom.

Lines 6-9. Data are from Table I or II. With pineapple, sweet potato and peaches, natural juices were incorporated into the infusion solutions. In such cases appropriate corrections were made for water and soluble solids.

Lines 10-12. Values calculated as indicated.

Lines 13&15. Data are from Table VI or VII.

Lines 14&16. Values are calculated as indicated.

Line 17. Moisture data are from Table VIII or IX. Dried weight data are from Tables VI or VII.

Lines 18-19. Values are calculated as indicated.

Line 20. Analytical soluble solids are from Table VIII or IX.

Lines 21-25. Values calculated as indicated.

Some selectivity must be excercised in alternative calculations for similar values. However, it is deemed appropriate to include lines 14A and 19A in these data. Line 14, "Calculation of Moisture in Infused Product", is based on a direct weighing, line 13, on the analysis of a control sample, line 5, plus an assumption of no change in state of product and on an accumulation of analysis and weighings involved as represented in line 12. Line 14A is based on two weighings, lines 13 and

TABLE X

Calculated Weight Data

Line	Product: Beef Rib Eye	Treatment 1	2	3	4
1	Control Product, gms	1000	1000	1000	1000
2	Moisture (% x wt)	631	631	631	631
3	Total Dry Solids (L1 - L2)	369	369	369	369
4	Soluble Solids (% x wt)	57	57	57	57
5	Insoluble Solids (L3 - L4)	312	312	312	312
6	Infusion Solution, gms	1000	1000	1000	1000
7	Water (% x wt)	606	747	872	978
8	Glycerine (% x wt)	240	150	75	0
9	Other Soluble Solids (% x wt)	154	103	53	22
10	Total System Water (L2 + L7)	1237	1378	1503	1609
11	Total System Soluble Solids (L4 + L8 + L9)	451	310	185	79
12	Percent Moisture in Aqueous Solution (L10 ÷ [L10 + L11] x 100)	73.3	81.6	89.0	95.3
13	Infused Drained Weight, gms	1175	1074	1047	1034
14	Calculated Infused Product Moisture ([L13 - L5] x L12/100)	633	638	654	688
14A	Calculated Infused Product Moisture (L13 - L15 + L17)	704	656	648	707
15	Dried Product Weight, gms	847	617	518	403
16	Calculated Dried Product Moisture, gms (L14 - L13 + L15)	305	181	125	57
17	Analytical Dried Product Moisture (L15 x % Moisture/100)	376	199	119	76
18	Calculated Soluble Solids (L13 - L14 - L5)	230	124	81	34
19	Calculated Soluble Solids (L15 - L17 - L5)	159	106	87	15
19A	Calculated Soluble Solids ([L14A x L11] ÷ L10)	257	148	80	35
20	Analytical Soluble Solids (L15 x % Soluble Solids/100)	174	112	95	41
21	Insoluble Solids (L15 - L17 - L20)	301	306	304	286
22	Expected Internal Solution (L15 - L5)	535	305	206	91
23	Analytical Internal Solution (L17 + L20)	546	311	214	117
24	Calculated Glycerol Dried Product, gm ([L14A x L8] ÷ L10)	137	72	32	0
25	Calculated Glycerol Dried Product, % (L24 ÷ L15 x 100)	16.0	11.6	6.2	0

TABLE XI

Calculated Weight Data

Line	Product: Ground Beef	Treatment 1	2	3	4
1	Control Product, gms	1000	1000	1000	1000
2	Moisture (% x wt)	622	622	622	622
3	Total Dry Solids (L1 - L2)	378	378	378	378
4	Soluble Solids (% x wt)	48	48	48	48
5	Insoluble Solids (L3 - L4)	330	330	330	330
6	Infusion Solution, gms	1000	1000	1000	1000
7	Water (% x wt)	636	777	888	978
8	Glycerine (% x wt)	210	120	60	0
9	Other Soluble Solids (% x wt)	154	103	52	22
10	Total System Water (L2 + L7)	1258	1399	1510	1600
11	Total System Soluble Solids (L4 + L8 + L9)	412	271	160	70
12	Percent Moisture in Aqueous Solution (L10 ÷ [L10 + L11] x 100)	75.3	83.8	90.4	95.8
13	Infused Drained Weight, gms	1156	1121	1096	1080
14	Calculated Infused Product Moisture ([L13 - L5] x L12/100)	622	663	692	719
14A	Calculated Infused Product Moisture (L13 - L15 + L17)	689	701	728	726
15	Dried Product Weight, gms	851	629	488	439
16	Calculated Dried Product Moisture, gms (L14 - L13 + L15)	317	171	84	78
17	Analytical Dried Product Moisture (L15 x % Moisture/100)	384	209	120	85
18	Calculated Soluble Solids (L13 - L14 - L5)	204	128	74	31
19	Calculated Soluble Solids (L15 - L17 - L5)	137	90	38	24
19A	Calculated Soluble Solids ([L14A x L11] ÷ L10)	226	136	77	32
20	Analytical Soluble Solids (L15 x % Soluble Solids/100)	241	162	94	54
21	Insoluble Solids (L15 - L17 - L20)	226	258	274	300
22	Expected Internal Solution (L15 - L5)	521	299	158	109
23	Analytical Internal Solution (L17 + L20)	625	371	214	139
24	Calculated Glycerol Dried Product, gm ([L14A x L8] ÷ L10)	115	60	29	0
25	Calculated Glycerol Dried Product, % (L24 ÷ L15 x 100)	13.5	9.5	5.9	0

TABLE XII

Calculated Weight Data

Line	Product: Chicken	Treatment 1	2	3	4
1	Control Product, gms	1000	1000	1000	1000
2	Moisture (% x wt)	707	707	707	707
3	Total Dry Solids (L1 - L2)	293	293	293	293
4	Soluble Solids (% x wt)	62	62	62	62
5	Insoluble Solids (L3 - L4)	231	231	231	231
6	Infusion Solution, gms	1000	1000	1000	1000
7	Water (% x wt)	496	672	832	943
8	Glycerine (% x wt)	300	200	100	30
9	Other Soluble Solids (% x wt)	204	128	68	27
10	Total System Water (L2 + L7)	1203	1379	1539	1650
11	Total System Soluble Solids (L4 + L8 + L9)	566	390	230	119
12	Percent Moisture in Aqueous Solution (L10 ÷ [L10 + L11] x 100)	68.0	78.0	87.0	93.3
13	Infused Drained Weight, gms	1107	1084	1069	1041
14	Calculated Infused Product Moisture ([L13 - L5] x L12/100)	596	665	729	756
14A	Calculated Infused Product Moisture (L13 - L15 + L17)	647	711	720	780
15	Dried Product Weight, gms	859	635	512	365
16	Calculated Dried Product Moisture, gms (L14 - L13 + L15)	348	216	172	80
17	Analytical Dried Product Moisture (L15 x % Moisture/100)	399	262	163	104
18	Calculated Soluble Solids (L13 - L14 - L5)	280	188	109	54
19	Calculated Soluble Solids (L15 - L17 - L5)	229	142	118	30
19A	Calculated Soluble Solids ([L14A x L11] ÷ L10)	304	201	108	56
20	Analytical Soluble Solids (L15 x % Soluble Solids/100)	225	162	129	60
21	Insoluble Solids (L15 - L17 - L20)	235	211	220	201
22	Expected Internal Solution (L15 - L5)	628	404	281	134
23	Analytical Internal Solution (L17 + L20)	624	424	292	164
24	Calculated Glycerol Dried Product, gm ([L14A x L8] ÷ L10)	161	103	47	14
25	Calculated Glycerol Dried Product, % (L24 ÷ L15 x 100)	19.0	16.0	9.2	3.8

TABLE XIII

Calculated Weight Data

Line	Product: Pork Tenderloin	Treatment 1	2	3	4
1	Control Product, gms	1000	1000	1000	1000
2	Moisture (% x wt)	678	678	678	678
3	Total Dry Solids (L1 - L2)	322	322	322	322
4	Soluble Solids (% x wt)	58	58	58	58
5	Insoluble Solids (L3 - L4)	264	264	264	264
6	Infusion Solution, gms	1000	1000	1000	1000
7	Water (% x wt)	581	722	857	973
8	Glycerine (% x wt)	240	150	75	0
9	Other Soluble Solids (% x wt)	179	128	68	27
10	Total System Water (L2 + L7)	1259	1400	1535	1651
11	Total System Soluble Solids (L4 + L8 + L9)	477	336	201	85
12	Percent Moisture in Aqueous Solution (L10 ÷ [L10 + L11] x 100)	72.5	80.6	88.4	95.1
13	Infused Drained Weight, gms	1136	1122	1077	1040
14	Calculated Infused Product Moisture ([L13 - L5] x L12/100)	632	692	719	738
14A	Calculated Infused Product Moisture (L13 - L15 + L17)	675	723	745	733
15	Dried Product Weight, gms	869	635	472	408
16	Calculated Dried Product Moisture, gms (L14 - L13 + L15)	365	205	114	106
17	Analytical Dried Product Moisture (L15 x % Moisture/100)	408	236	140	101
18	Calculated Soluble Solids (L13 - L14 - L5)	240	166	94	38
19	Calculated Soluble Solids (L15 - L17 - L5)	197	135	68	43
19A	Calculated Soluble Solids ([L14A x L11] ÷ L10)	256	173	98	38
20	Analytical Soluble Solids (L15 x % Soluble Solids/100)	239	147	117	53
21	Insoluble Solids (L15 - L17 - L20)	225	246	195	254
22	Expected Internal Solution (L15 - L5)	605	371	208	144
23	Analytical Internal Solution (L17 + L20)	644	389	277	154
24	Calculated Glycerol Dried Product, gm ([L14A x L8] ÷ L10)	129	77	36	0
25	Calculated Glycerol Dried Product, % (L24 ÷ L15 x 100)	15.0	12.0	7.7	0

TABLE XIV

Calculated Weight Data

Line	Product: Omelet	Grams	Treatment 1	2	3	4
1	Control Product, Cooked	932				
	a) Moisture	666				
	b) Total Dry Solids	266				
	c) Soluble Solids	0				
	d) Insoluble Solids	266				
	e) Fat	123				
2	Initial Product					
	a) Base[1]		662	724	763.5	796
	b) Water		160	174	185	193
	c) Glycerine		175	100	50	10
	d) Other Soluble Solids		3	2	1.5	1
3	Cooked Weight		952	953	947	925
4	Dried Weight		857	622	478	390
5	Dried Product Moisture (Analysis)		418	275	161	94
6	Dried Product Total Dry Solids (L4 - L5)		439	347	317	296
7	Expected Total Dry Solids ([L1b x % Base] + [L2c + L2d])		354	295	255	233
8	Calculated Dried Product Moisture (L4 - L7)		461	281	174	116
9	Dried Product Soluble Solids (Analysis)		246	175	137	90
10	Expected Soluble Solids (L7 - [L1d x % Base])		178	102	52	11
11	Calculated Soluble Solids ([L4 - L5] - [L1d x % Base])		263	154	114	84
12	Expected Internal Solution (L4 - [L1b x % Base])		681	429	275	178
14	Analytical Internal Solution (L5 + L9 - [L1c x % Base])		664	450	298	184
15	Calculated Insoluble Solids (L4 - L5 - L9)		193	172	180	206
16	Glycerol in Dried Product, % ([L2c ÷ L4] x 100)		20	16	10	3

1) Base is shown in Table III as total of egg, salt and pepper.

TABLE XV

Calculated Weight Data

Line	Product: Carrots	Treatment 1	2	3	4
1	Control Product, gms	1000	1000	1000	1000
2	Moisture (% x wt)	901	901	901	901
3	Total Dry Solids (L1 - L2)	99	99	99	99
4	Soluble Solids (% x wt)	63	63	63	63
5	Insoluble Solids (L3 - L4)	36	36	36	36
6	Infusion Solution, gms	1000	1000	1000	1000
7	Water (% x wt)	504	695	847	939
8	Glycerine (% x wt)	450	275	137	55
9	Other Soluble Solids (% x wt)	46	30	16	6
10	Total System Water (L2 + L7)	1405	1596	1748	1840
11	Total System Soluble Solids (L4 + L8 + L9)	559	368	216	124
12	Percent Moisture in Aqueous Solution (L10 ÷ [L10 + L11] x 100)	71.5	81.3	89.0	93.7
13	Infused Drained Weight, gms	1070	1026	1007	971
14	Calculated Infused Product Moisture ([L13 - L5] x L12/100)	739	805	864	876
14A	Calculated Infused Product Moisture (L13 - L15 + L17)	667	735	838	850
15	Dried Product Weight, gms	846	589	310	191
16	Calculated Dried Product Moisture, gms (L14 - L13 + L15)	515	368	167	96
17	Analytical Dried Product Moisture (L15 x % Moisture/100)	443	298	141	70
18	Calculated Soluble Solids (L13 - L14 - L5)	295	185	107	59
19	Calculated Soluble Solids (L15 - L17 - L5)	367	255	133	85
19A	Calculated Soluble Solids ([L14A x L11] ÷ L10)	265	170	104	57
20	Analytical Soluble Solids (L15 x % Soluble Solids/100)	353	233	137	77
21	Insoluble Solids (L15 - L17 - L20)	50	58	32	44
22	Expected Internal Solution (L15 - L5)	810	553	274	155
23	Analytical Internal Solution (L17 + L20)	796	531	278	147
24	Calculated Glycerol Dried Product, gm ([L14A x L8] ÷ L10)	214	127	66	25
25	Calculated Glycerol Dried Product, % (L24 ÷ L15 x 100)	25.0	22.0	22.0	13.0

TABLE XVI

Calculated Weight Data

Line	Product: Pineapple	Treatment 1	2	3	4
1	Control Product, gms	1000	1000	1000	1000
2	Moisture (% x wt)	844	844	844	844
3	Total Dry Solids (L1 - L2)	156	156	156	156
4	Soluble Solids (% x wt)	144	144	144	144
5	Insoluble Solids (L3 - L4)	12	12	12	12
6	Infusion Solution, gms	1000	1000	1000	1000
7	Water (% x wt)	442	639	745	853
8	Glycerine (% x wt)	480	250	125	0
9	Other Soluble Solids (% x wt)	78	111	130	147
10	Total System Water (L2 + L7)	1286	1483	1589	1697
11	Total System Soluble Solids (L4 + L8 + L9)	702	505	399	291
12	Percent Moisture in Aqueous Solution (L10 ÷ [L10 + L11] x 100)	64.7	74.6	79.9	85.4
13	Infused Drained Weight, gms	1187	1175	1087	1070
14	Calculated Infused Product Moisture ([L13 - L5] x L12/100)	760	868	859	904
14A	Calculated Infused Product Moisture (L13 - L15 + L17)	772	860	832	915
15	Dried Product Weight, gms	912	616	400	241
16	Calculated Dried Product Moisture, gms (L14 - L13 + L15)	485	309	172	75
17	Analytical Dried Product Moisture (L15 x % Moisture/100)	497	301	145	86
18	Calculated Soluble Solids (L13 - L14 - L5)	415	295	216	154
19	Calculated Soluble Solids (L15 - L17 - L5)	403	303	243	143
19A	Calculated Soluble Solids ([L14A x L11] ÷ L10)	421	293	209	157
20	Analytical Soluble Solids (L15 x % Soluble Solids/100)	394	293	212	139
21	Insoluble Solids (L15 - L17 - L20)	21	22	43	16
22	Expected Internal Solution (L15 - L5)	900	604	388	229
23	Analytical Internal Solution (L17 + L20)	891	594	357	225
24	Calculated Glycerol Dried Product, gm ([L14A x L8] ÷ L10)	288	145	65	0
25	Calculated Glycerol Dried Product, % (L24 ÷ L15 x 100)	31.6	23.5	16.4	0

TABLE XVII

Calculated Weight Data

Line	Product: Turkey	Treatment 1	2	3	4
1	Control Product, gms	1000	1000	1000	1000
2	Moisture (% x wt)	677	677	677	677
3	Total Dry Solids (L1 - L2)	323	323	323	323
4	Soluble Solids (% x wt)	51	51	51	51
5	Insoluble Solids (L3 - L4)	272	272	272	272
6	Infusion Solution, gms	1000	1000	1000	1000
7	Water (% x wt)	481	662	832	933
8	Glycerine (% x wt)	350	225	100	30
9	Other Soluble Solids (% x wt)	169	113	68	37
10	Total System Water (L2 + L7)	1158	1339	1509	1610
11	Total System Soluble Solids (L4 + L8 + L9)	570	389	219	118
12	Percent Moisture in Aqueous Solution (L10 ÷ [L10 + L11] x 100)	67.0	77.5	87.3	93.2
13	Infused Drained Weight, gms	1069	1062	1040	1038
14	Calculated Infused Product Moisture ([L13 - L5] x L12/100)	534	612	670	714
14A	Calculated Infused Product Moisture (L13 - L15 + L17)	595	656	694	736
15	Dried Product Weight, gms	885	677	500	396
16	Calculated Dried Product Moisture, gms (L14 - L13 + L15)	350	227	130	72
17	Analytical Dried Product Moisture (L15 x % Moisture/100)	411	272	154	94
18	Calculated Soluble Solids (L13 - L14 - L5)	263	178	98	52
19	Calculated Soluble Solids (L15 - L17 - L5)	202	134	74	30
19A	Calculated Soluble Solids ([L14A x L11] ÷ L10)	293	191	101	54
20	Analytical Soluble Solids (L15 x % Soluble Solids/100)	303	211	122	67
21	Insoluble Solids (L15 - L17 - L20)	171	195	224	235
22	Expected Internal Solution (L15 - L5)	613	405	228	124
23	Analytical Internal Solution (L17 + L20)	714	482	276	161
24	Calculated Glycerol Dried Product, gm ([L14A x L8] ÷ L10)	180	110	46	14
25	Calculated Glycerol Dried Product, % (L24 ÷ L15 x 100)	20.0	16.0	9.2	3.5

TABLE XVIII

Calculated Weight Data

Line	Product: Halibut	Treatment 1	2	3	4
1	Control Product, gms	1000	1000	1000	1000
2	Moisture (% x wt)	795	795	795	795
3	Total Dry Solids (L1 - L2)	205	205	205	205
4	Soluble Solids (% x wt)	37	37	37	37
5	Insoluble Solids (L3 - L4)	168	168	168	168
6	Infusion Solution, gms	1000	1000	1000	1000
7	Water (% x wt)	568	773	879	981
8	Glycerine (% x wt)	350	180	90	0
9	Other Soluble Solids (% x wt)	82	47	31	19
10	Total System Water (L2 + L7)	1363	1568	1674	1776
11	Total System Soluble Solids (L4 + L8 + L9)	469	264	158	56
12	Percent Moisture in Aqueous Solution (L10 ÷ [L10 + L11] x 100)	74.4	85.7	91.3	96.8
13	Infused Drained Weight, gms	1240	1317	1257	1106
14	Calculated Infused Product Moisture ([L13 - L5] x L12/100)	798	985	994	908
14A	Calculated Infused Product Moisture (L13 - L15 + L17)	857	1032	1019	899
15	Dried Product Weight, gms	838	605	411	293
16	Calculated Dried Product Moisture, gms (L14 - L13 + L15)	396	273	148	95
17	Analytical Dried Product Moisture (L15 x % Moisture/100)	455	320	173	86
18	Calculated Soluble Solids (L13 - L14 - L5)	274	164	95	30
19	Calculated Soluble Solids (L15 - L17 - L5)	215	117	70	39
19A	Calculated Soluble Solids ([L14A x L11] ÷ L10)	295	174	96	28
20	Analytical Soluble Solids (L15 x % Soluble Solids/100)	184	117	67	31
21	Insoluble Solids (L15 - L17 - L20)	199	168	171	176
22	Expected Internal Solution (L15 - L5)	670	437	243	125
23	Analytical Internal Solution (L17 + L20)	639	437	240	117
24	Calculated Glycerol Dried Product, gm ([L14A x L8] ÷ L10)	220	119	55	0
25	Calculated Glycerol Dried Product, % (L24 ÷ L15 x 100)	26	20	13	0

TABLE XIX

Calculated Weight Data

Line	Product: Ham	Treatment 1	2	3	4
1	Control Product, gms	1000	1000	1000	1000
2	Moisture (% x wt)	701	701	701	701
3	Total Dry Solids (L1 - L2)	299	299	299	299
4	Soluble Solids (% x wt)	118	118	118	118
5	Insoluble Solids (L3 - L4)	181	181	181	181
6	Infusion Solution, gms	1000	1000	1000	1000
7	Water (% x wt)	600	800	895	988
8	Glycerine (% x wt)	309	151	77	0
9	Other Soluble Solids (% x wt)	91	49	28	12
10	Total System Water (L2 + L7)	1301	1501	1596	1689
11	Total System Soluble Solids (L4 + L8 + L9)	518	318	223	130
12	Percent Moisture in Aqueous Solution (L10 ÷ [L10 + L11] x 100)	71.5	82.5	87.7	92.9
13	Infused Drained Weight, gms	1008	1021	1034	1037
14	Calculated Infused Product Moisture ([L13 - L5] x L12/100)	591	693	748	795
14A	Calculated Infused Product Moisture (L13 - L15 + L17)	583	674	738	793
15	Dried Product Weight, gms	887	670	502	378
16	Calculated Dried Product Moisture, gms (L14 - L13 + L15)	470	342	216	136
17	Analytical Dried Product Moisture (L15 x % Moisture/100)	462	323	206	134
18	Calculated Soluble Solids (L13 - L14 - L5)	236	147	105	61
19	Calculated Soluble Solids (L15 - L17 - L5)	244	166	115	63
19A	Calculated Soluble Solids ([L14A x L11] ÷ L10)	232	143	103	61
20	Analytical Soluble Solids (L15 x % Soluble Solids/100)	218	147	104	62
21	Insoluble Solids (L15 - L17 - L20)	207	200	192	182
22	Expected Internal Solution (L15 - L5)	706	489	321	197
23	Analytical Internal Solution (L17 + L20)	680	470	310	196
24	Calculated Glycerol Dried Product, gm ([L14A x L8] ÷ L10)	138	68	36	0
25	Calculated Glycerol Dried Product, % (L24 ÷ L15 x 100)	16.0	10.0	7.2	0

TABLE XX

Calculated Weight Data

Line	Product: Bologna	Grams	Treatment 1	2	3	4
1	Control Product, Cooked	907				
	a) Moisture	469				
	b) Total Dry Solids	438				
	c) Soluble Solids	53				
	d) Insoluble Solids	385				
	e) Fat	224				
2	Initial Product					
	a) Base[1]		805	805	805	805
	b) Water		0	81	128	137
	c) Glycerine		144	73	23	0
	d) Other Soluble Solids		51	41	44	58
3	Cooked Weight		946	934	920	907
4	Dried Weight		875	711	584	499
5	Dried Product Moisture (Analysis)		301	214	119	53
6	Dried Product Total Dry Solids (L4 - L5)		574	497	465	446
7	Expected Total Dry Solids (L1b + L2c)		582	511	461	438
8	Calculated Dried Product Moisture (L4 - L7)		293	200	123	61
9	Dried Product Soluble Solids (Analysis)		320	228	165	56
10	Expected Soluble Solids (L7 - L1d)		197	126	76	53
11	Calculated Soluble Solids (L4 - L5 - L1d)		189	112	80	61
12	Expected Internal Solution (L4 - L1d)		490	326	199	114
14	Analytical Internal Solution (L5 + L9)		621	442	284	109
15	Calculated Insoluble Solids (L4 - L5 - L9) or (L4 - L14)		254	269	300	390
16	Glycerol in Dried Product, % ([L2c ÷ L4] x 100)		16	10	4	0

1) Base is shown in Table IV as total less glycerol, salt, seasoning and potassium sorbate.

TABLE XXI

Calculated Weight Data

Line	Product: Pancake	Grams	Treatment 1	2	3	4
1	Control Product, Cooked	879				
	a) Moisture	414				
	b) Total Dry Solids	465				
	c) Soluble Solids	121				
	d) Insoluble Solids	344				
	e) Fat	27				
2	Initial Product					
	a) Base[1]		500	500	500	500
	b) Water		372	423	448.5	499
	c) Glycerine		125	75	50	0
	d) Other Soluble Solids		3	2	1.5	1
3	Cooked Weight		862	900	891	881
4	Dried Weight		862	738	626	518
5	Dried Product Moisture (Analysis)		272	200	116	52
6	Dried Product Total Dry Solids (L4 - L5)		590	538	510	466
7	Expected Total Dry Solids (L1b + L2c)		593	542	516	466
8	Calculated Dried Product Moisture (L4 - L7)		269	196	110	52
9	Dried Product Soluble Solids (Analysis)		244	194	148	114
10	Expected Soluble Solids (L7 - L1d)		249	198	172	122
11	Calculated Soluble Solids (L4 - L5 - L1d)		246	194	166	122
12	Expected Internal Solution (14 - L1d)		518	394	282	174
14	Analytical Internal Solution (L5 + L9)		516	394	264	166
15	Calculated Insoluble Solids (L4 - L5 - L9)		347	344	362	352
16	Glycerol in Dried Product, % ([L2c ÷ L4] x 100)		14.5	10.1	8.0	0

1) Base is shown in Table V as pancake mix.

TABLE XXII

Calculated Weight Data

Line	Product: Sweet Potatoes	Treatment 1	2	3	4
1	Control Product, gms	1000	1000	1000	1000
2	Moisture (% x wt)	718	718	718	718
3	Total Dry Solids (L1 - L2)	282	282	282	282
4	Soluble Solids (% x wt)	208	208	208	208
5	Insoluble Solids (L3 - L4)	74	74	74	74
6	Infusion Solution, gms	1000	1000	1000	1000
7	Water (% x wt)	414	552	660	767
8	Glycerine (% x wt)	457	278	140	0
9	Other Soluble Solids (% x wt)	131	170	200	233
10	Total System Water (L2 + L7)	1132	1270	1378	1485
11	Total System Soluble Solids (L4 + L8 + L9)	796	656	548	441
12	Percent Moisture in Aqueous Solution (L10 ÷ [L10 + L11] x 100)	58.7	65.9	71.5	77.1
13	Infused Drained Weight, gms	987	1001	1002	1009
14	Calculated Infused Product Moisture ([L13 - L5] x L12/100)	536	611	664	721
14A	Calculated Infused Product Moisture (L13 - L15 + L17)	576	632	697	739
15	Dried Product Weight, gms	856	638	483	356
16	Calculated Dried Product Moisture, gms (L14 - L13 + L15)	405	248	145	68
17	Analytical Dried Product Moisture (L15 x % Moisture/100)	445	269	178	86
18	Calculated Soluble Solids (L13 - L14 - L5)	377	316	265	214
19	Calculated Soluble Solids (L15 - L17 - L5)	337	295	231	196
19A	Calculated Soluble Solids ([L14A x L11] ÷ L10)	405	326	277	219
20	Analytical Soluble Solids (L15 x % Soluble Solids/100)	324	277	199	169
21	Insoluble Solids (L15 - L17 - L20)	87	92	106	101
22	Expected Internal Solution (L15 - L5)	782	564	409	282
23	Analytical Internal Solution (L17 + L20)	769	546	377	255
24	Calculated Glycerol Dried Product, gm ([L14A x L8] ÷ L10)	232	138	71	0
25	Calculated Glycerol Dried Product, % (L24 ÷ L15 x 100)	27.1	21.6	14.7	0

TABLE XXIII

Calculated Weight Data

Line	Product: Peaches	Treatment 1	2	3	4
1	Control Product, gms	1000	1000	1000	1000
2	Moisture (% x wt)	862	862	862	862
3	Total Dry Solids (L1 - L2)	138	138	138	138
4	Soluble Solids (% x wt)	133	133	133	133
5	Insoluble Solids (L3 - L4)	5	5	5	5
6	Infusion Solution, gms	1000	1000	1000	1000
7	Water (% x wt)	471	675	785	863
8	Glycerine (% x wt)	457	225	100	10
9	Other Soluble Solids (% x wt)	72	100	115	127
10	Total System Water (L2 + L7)	1333	1537	1647	1725
11	Total System Soluble Solids (L4 + L8 + L9)	662	458	348	270
12	Percent Moisture in Aqueous Solution (L10 ÷ [L10 + L11] x 100)	66.8	77.0	82.6	86.4
13	Infused Drained Weight, gms	1095	1108	1083	1081
14	Calculated Infused Product Moisture ([L13 - L5] x L12/100)	728	849	890	930
14A	Calculated Infused Product Moisture (L13 - L15 + L17)	765	863	855	908
15	Dried Product Weight, gms	834	589	362	239
16	Calculated Dried Product Moisture, gms (L14 - L13 + L15)	467	330	169	88
17	Analytical Dried Product Moisture (L15 x % Moisture/100)	508	344	134	66
18	Calculated Soluble Solids (L13 - L14 - L5)	361	254	188	146
19	Calculated Soluble Solids (L15 - L17 - L5)	325	240	223	168
19A	Calculated Soluble Solids ([L14A x L11] ÷ L10)	380	257	181	142
20	Analytical Soluble Solids (L15 x % Soluble Solids/100)	287	214	151	98
21	Insoluble Solids (L15 - L17 - L20)	43	31	77	75
22	Expected Internal Solution (L15 - L5)	829	584	357	234
23	Analytical Internal Solution (L17 + L20)	791	558	285	164
24	Calculated Glycerol Dried Product, gm ([L14A x L8] ÷ L10)	262	126	52	5.2
25	Calculated Glycerol Dried Product, % (L24 ÷ L15 x 100)	31.4	21.4	14.4	2.2

15, and a moisture determination included under line 17. Therefore, line 14A should have substantially less chance of error than line 14. This substitution of line 14A for the equation in line 18 automatically gives line 19. Thus the difference between line 18 and line 19 is consistently the difference between line 14 and line 14A. Line 19A was included since it represents another pathway of calculation for soluble solids. In this case, however, line 19 is considered to have substantially less chance of error than line 19A since fewer analysis are involved.

Calculations performed on formulated products, namely French omelet (Table XIV), bologna (Table XX) and pancake (Table XXI) require no additional explanation. The control for each product is represented by "Treatment 4" after cooking but prior to drying. See Table III, IV or V for formulations, Table VI or VII for drying and Table VIII or IX for subsequent data. A special correction is necessary to compensate for variations in the base composition used for intermediate moisture French omelet, see Table XIV.

XI. Discussion of Calculated Weight Data of Infused Products

As noted in the preceding section, the moisture contents of the infused products were calculated in two ways. Line 14 is based on the observed weight of the drained infused product, the analytical value for the insoluble solids in the control, and a fraction involving the determined content of water in the pre-infused food plus the water in the infusion solution and the soluble solids in this solution plus the determined soluble solids in the pre-infused food. In addition to analytical accuracy this calculation assumes that all soluble components are uniformly dissolved in the aqueous phase which has equilibrated throughout the solid structure of the food. In addition it is assumed that the solubility of the soluble and insoluble components of the control food has not been changed by the infusion solution. Fewer assumptions are involved in calculating the moisture content of the infused product according to Line 14A. Here moisture is based on the observed weights of the infused product before and after drying and the analytical moisture of the dried product based on four treatments for each of 11 infused items, the difference between moisture calculated in Lines 14 and 14A did not exceed ± 5% in 32 samples and ± 10% in 43 samples (the remaining sample differed by 12%). While

the moisture content of the infused product is not a sensitive criterion for the validity of the above assumptions, lines 14 and 14A suggest that water behaves in a predictable manner in the infusion and in subsequent operations.

Differences in the calculated and analytical moisture contents of the end items as shown in lines 16 and 17, respectively, reveal the same pattern as shown for the moisture concentrations as calculated for the infused products prior to drying, lines 14 and 14A. In fact, if the value for line 14A is substituted for line 14 in calculating line 16, the resulting values equal precisely those of line 17.

Insoluble solids can be predicted on the basis of the insoluble residue of the control, line 5, if it is assumed that the presence of glycerol and salt in the intermediate moisture products do not change the solubility of the insoluble fractions. The analytical procedure for soluble (or insoluble) solids is based on exhaustive extraction and hence cannot reveal a reduction of solubility in the end item per se. Insoluble solids are also calculated in line 21 on the basis of total weight (line 15) minus soluble solids (line 20) minus moisture by analysis (line 17). Comparison of values for lines 5 and 21 is inconclusive. Greatest divergence is seen with fruits and vegetables in which values of line 21 are substantially greater than line 5.

The soluble solids including glycerol contained in the end items following the four partial drying treatments are variously calculated in lines 18, 19, 19A and 20. Line 18 is based on the weight and calculated moisture contents of the infused products prior to any drying and weight of insoluble material present which is assumed to be the same as in the control. In line 19 the weight of soluble material is calculated from the weight of the end item minus its moisture as determined by analysis minus the insoluble solids assumed to be present. Lines 18 and 19 differ by the same numerical amount as noted between 14 and 14A. In line 19A the soluble components present are calculated on the assumption that with complete equilibration the fraction of the total soluble material present in the infused product (and hence in the end items) is directly proportional to the fraction of the total water in the system which is present in the infused product. Line 20 shows the weight of soluble material in the various end items as determined by analysis.

With few exceptions, values calculated according to lines 18 and 19A are in good agreement. It can be shown that lines 18 and 19A differ by an amount equal to the difference between lines 14 and 14A times a factor obtained by dividing the total soluble matter in the system (line 11) by the total water in the system (line 10). Comparison of line 20 with either line 18 or line 19A reveals poor agreement without a clear pattern for the amount or direction of the disparity.

Irregular or unpredictable distribution of soluble components could result from incomplete equilibration during the soaking operation. In analyzing the available observations for this possibility, the ratios of soluble material to water in the controls (line 4/line 2) were compared with corresponding ratios for the infusion solutions (lines 8 and 9/line 7). It was noted that the infusion solutions for Treatment 1 contain a higher concentration of soluble material than solutions for the other treatments and that the ratios for Treatment 1 solutions exceeded the ratios noted for the control samples. It follows therefrom that products subjected to Treatment 1 have a greater chance of incomplete equilibration than items exposed to other treatments. Since the values for the soluble components in line 19A are based on the assumption of complete equilibration, it follows that incomplete equilibration should result in line 20 being substantially lower than line 19A. This hypothesis is consistent with observations for diced beef, chicken white meat, halibut, sweet potatoes and peaches. However, neither the experimental systems nor the analytical procedures are sufficiently controlled to permit a definite conclusion on the completeness of equilibration.

Internal solution may be treated as the sum of moisture and soluble solids as in line 24, which utilizes analytical results for both moisture and soluble material. Also, internal solution is equivalent to the weight of the end item minus the weight of insoluble material present. In line 22 the insoluble matter is assumed to equal that of the control. Comparison of values for lines 22 and 23 indicate fair agreement; 31 of the 44 corresponding values for the 11 infused items differ by less than 10%. As will be noted subsequently the composition of the internal solution is the primary factor controlling water activity in treatments 1, 2 and 3. In Treatment 4 the nature of the insoluble phase may be a significant factor.

XII. Discussion of Calculated Data for Formulated Products

In the formulated products, omelet (Table XIV), bologna (Table XX), and pancake (Table XXI), it is found that calculated moistures (line 8) are very comparable to analytical data (line 5). The values for soluble solids (lines 9, 10 and 11) are highly variable except for pancakes. In the case of the pancake product, all data are similar for moisture, soluble solids and insoluble solids. In the case of bologna, the analytical soluble solids are higher than calculated values with corresponding decreases in insoluble solids. In this product the percentage of salt was increased as well as the percentage of glycerol for the products having higher levels of internal solution. These increases are of the same order as the decreases in insoluble solids which indicates that insoluble materials were solubilized. In the case of French omelet, calculated moistures were lower than analytical values for all treatments except treatment No. 1 which was the highest internal solution product. No explanation is evident for this discrepancy in the data. Analytical soluble solids for French omelet were all found to be higher than calculated which indicates a high degree of solubilization of insoluble materials. This is further evidenced by the lower insoluble fraction than was originally found. Repeated observations on the original French omelet have always shown the soluble solids to be negative. Therefore, it must be assumed that glycerol is effective in solubilizing materials found in the omelet product. It is also apparent that glycerol has no effect on solubilizing materials found in the pancake.

XIII. Discussion of Calculated Data for Glycerol

For the infused products the weight of glycerol shown in line 24 is calculated on the same assumption as used for soluble solids in line 19A and should have an equivalent level of validity. With the three formulated items the weight of glycerol present equals the weight incorporated into the formulation (line 2C). As a very rough generalization the weight of glycerol present in Treatment 2 product is half of Treatment 1 and Treatment 3 is one-half that of Treatment 2. In more than half the Treatment 4 samples no glycerol is present. Since there is a progressive loss of weight of end items from Treatment 1 through Treatment 4, the average glycerol concentration per unit weight of product falls from 20.7% for Treatment 1 to 15.7% for

Treatment 2 and to 10.4 and 1.8% for Treatments 3 and 4, respectively. Each of these average values represent a broad range. It is noteworthy that with Treatment 1 through 3 there is an average decrease of only 5 percentage units with each successive treatment. Even with products having a percentage glycerol content consistently below the indicated average, such as ground and diced beef, ham and bologna, it is necessary to achieve a level of drying near that of Treatment 2 in order to reduce the glycerol content to approximately 10%. Even at the Treatment 3 level of drying, 5 of the 14 products had a glycerol concentration in excess of 10%. This does not provide an optimistic picture in view of the deterioration in acceptability caused by drying or by the presence of moderate concentrations of glycerol.

XIV. General Discussion of Treatment Effects on Internal Solutions

Primary control of water activity rests with the internal solution although as is evident from Tables X through XXIII it is probable that a significant contribution may be forthcoming from the insoluble material, especially at the Treatment 4 level of drying. As seen from the following compilation, the internal solution represents a high percentage of the end item, especially in the Treatment 1 and 2 groups:

Table XXIV

Summary of Internal Solution Data

	Treatment			
	1	2	3	4
Weight Product g. (ave)	863	641	475	365
Weight Internal Solution g. (ave)	680	457	280	164
Internal Solution as % of Product (ave)	78.8	71.3	59.0	44.9
Water as % of Internal Solution (ave)	60.8	58.5	53.2	51.6
Glycerol as % of Internal Solution (ave)	26.1	21.6	16.2	3.0
A_W (ave)	0.839	0.824	0.815	0.795

The above summary is intended to illustrate several points. The loss in weight between Treatments 1 and 2 is all accounted for on the basis of internal solution. However, in attempting to maintain a constant A_W,

primarily by adjusting the amount of glycerol present, produces relatively small changes in the concentration of water or glycerol when calculated on the basis of the internal present. Essentially, the same picture prevails in the transition from Treatment 2 to 3 notwithstanding the fact that only about 40% of the weight of internal solution present in Treatment 1 remains. Based on average weights the water content of the internal solution for the four treatment levels adheres to the relationship:

Weight Water = (0.637) Internal Solution - 19.8

For glycerol the corresponding relationship is:

Weight Glycerol = (0.339) Internal Solution - 50.6

The preceding compilation also illustrates the fact that factor(s) other than glycerol become increasingly important in the transition from Treatment 1 to 4. The amount of glycerol present per 100 g of water in Treatment 1 can be expected to depress A_W to between 0.91 and 0.92. The difference with respect to the observed value of A_W must reflect the effect of other factors such as salt, other soluble materials and absorption plus capillary condensation for depressing A_W. Further calculations based on the glycerol and water present in Treatments 2, 3 and 4 can account for water activities of 0.922, 0.946 and 0.990, respectively. Obviously, the other factors gradually dominate the water activity under the conditions of this study.

XV. Effect of 3 Months Storage at 38°C

a) Internal Solution - There was no apparent change in internal solutions during storage of any of the products as shown in Tables XXV and XXVI. The differences observed are all within analytical error or expected normal product variance.

b) Moisture Content - Moisture values determined after 3 months storage at 38°C as shown in Tables XXVII and XXVIII were similar to the initial values before storage (see Tables VIII and IX). Although differences were found, there were approximately as many increases in moisture as there were decreases.

TABLE XXV

Internal Solution Levels Before and After Storage at 38°C for 3 Months -- Phase I

Product	Internal Solution[1] Initial %	Ratio[2]	% of Original	Loss 2 Kg/Cm² % Total Weight	Storage %	% of Change
Beef RibEye-Control	63.1	1.71				
Treatment 1	56.4	1.30	76	0	56.0	-0.4
2	40.2	.67	39	0	39.2	-1.0
3	29.0	.41	23	0	26.9	-2.1
4	8.4	.09	5	0	20.6	-2.0
Ground Beef-Control	62.2	1.64				
Treatment 1	55.6	1.25	76	0	53.6	-2.0
2	39.9	.66	40	0	38.8	-1.1
3	22.5	.29	18	0	21.0	-1.5
4	13.9	.16	10	0	12.1	-1.8
Chicken-Control	70.7	2.41				
Treatment 1	65.9	1.93	80	0	63.2	-2.7
2	53.9	1.17	49	0	51.0	-2.9
3	42.8	.75	31	0	43.3	+0.5
4	19.7	.25	10	0	22.1	+2.6
Tenderloin-Control	67.8	2.11				
Treatment 1	62.9	1.70	80	0	65.3	+2.4
2	49.3	.97	46	0	48.5	-0.8
3	31.8	.47	22	0	33.8	+2.0
4	21.1	.27	13	0	19.7	-1.4
Omelet-Control	71.6	2.52				
Treatment 1	66.9	2.02	80	3.2	65.7	-1.2
2	54.3	1.19	47	0	53.7	-0.6
3	40.6	.68	27	0	38.5	-2.1
4	27.2	.37	15	0	25.3	-1.9
Carrots-Control	90.1	9.10				
Treatment 1	88.3	7.55	83	9.0	89.5	+1.2
2	83.2	4.95	54	0.6	83.8	+0.6
3	68.1	2.13	23	0	69.6	+1.5
4	48.2	.93	10	0	47.5	-0.7
Pineapple-Control	84.4	5.41				
Treatment 1	82.9	4.85	90	11.0[3]	81.3	-1.6
2	74.7	2.95	55	4.8	75.6	+0.9
3	61.0	1.56	29	1.4	59.0	-2.0
4	35.3	.55	10	0	34.3	-1.0

1) Internal Solution = 100 less total dry solids of original product.
2) Ratio = % Internal Solution/100 - % Internal Solution.
3) Free juice in package after 1 week storage at 75°F.

TABLE XXVI

Internal Solution Levels Before and After Storage at 38°C for 3 Months - Phase II

Product	Internal Solution[1) Initial %	Ratio[2)	% of Original	Loss 2 Kg/Cm^2 % Total Weight	Storage %	% of Change
Turkey-Control	67.7	2.09				
Treatment 1	63.4	1.73	83	0	66.5	+0.5
2	52.3	1.10	52	0	52.4	+0.1
3	35.4	.55	27	0	35.0	-0.4
4	18.4	.23	11	0	15.4	-3.0
Halibut-Control	79.5	3.88				
Treatment 1	75.5	3.08	79	4.1	74.0	-1.0
2	66.1	1.95	52	0	63.1	-3.0
3	50.1	1.00	26	0	49.5	-0.6
4	30.0	.43	11	0	27.9	-2.1
Ham-Control	70.1	2.34				
Treatment 1	66.4	1.98	84	0	66.9	+0.5
2	55.3	1.24	53	0	53.6	-1.7
3	40.4	.68	29	0	39.4	-1.0
4	20.9	.26	11	0	18.8	-2.1
Bologna-Control	51.7	1.07				
Treatment 1	47.5	.90	84	0	47.2	-0.3
2	36.4	.57	53	0	36.3	-0.1
3	23.8	.31	29	0	24.6	+0.8
4	12.2	.14	13	0	12.5	+0.3
Pancake-Control	47.1	.89				
Treatment 1	47.1	.89	100	3.0	47.5	+0.5
2	35.6	.55	62	0	35.5	-0.2
3	24.8	.33	37	0	25.6	+0.8
4	10.0	.11	12	0	10.9	+0.9
SweetPotato-Control	71.8	2.55				
Treatment 1	67.8	2.11	83	4.7	69.5	+1.7
2	55.0	1.22	48	0	56.2	+1.1
3	41.6	.71	28	0	42.6	+1.0
4	25.2	.34	13	0	26.8	+1.6
Peaches-Control	86.2	6.25				
Treatment 1	83.4	5.02	81	4.9[3)	83.8	-0.4
2	77.1	3.37	54	3.9	77.4	+0.3
3	60.8	1.55	25	0	61.6	+0.8
4	37.8	.61	10	0	35.8	-2.0

1) Internal Solution = 100 less total dry solids of original product.
2) Ratio = % Internal Solution/100 - % Internal Solution.
3) Free juice in package after 1 week storage at 75°F.

c) Water Activity (A_w) - There was no conclusive change in the A_w values of products during 3 months storage at 38°C as shown by comparison of data in Tables VIII and IX with Tables XXVII and XXVIII. A_w values within $\pm$ 0.02 represent the sensitivity range of the instrument. An unaccountable difference occurs between Phase I and II. In Phase I, 26 out of 28 A_w values decreased, 16 by more than 0.02 unit. In Phase II no value decreased more than 0.02 while 19 out of 28 increased, 6 by more than 0.02 unit. Changes in A_w values would result from changes in the relationships of soluble solids to moisture. Such changes should be minimized by the use of hermetically sealed containers. This is further evidenced by comparison of the moisture data from Tables VIII and IX with corresponding values of Tables XXVII and XXVIII. There was no relatability between changes in water activity and change in moisture content. Therefore, it is believed that differences observed were due to sampling variables and analytical error and not to storage effect.

d) Browning (% Fluorescence) - Data for browning shown in Tables XXVII and XXVIII indicate no serious browning problems during 3 months storage at 38°C except in products containing high levels of reducing sugars. This is evident since the only products which did show increases in browning are products containing sugars; pancake, sweet potato, peaches and treatment 4 bologna. The browning observed in pancake, sweet potato and peaches is apparently inherent in these products since similar but slightly lower values were observed in initial products. This was not the case for treatment 4 bologna, however, and this browning is, therefore, due to storage effect. Treatment 4 was the only bologna formula which contained sugar added as corn syrup solids.

e) Oxidative Rancidity (TBA) - There was no evidence of excessive fat deterioration of stored products as indicated by the thio barbituric acid (TBA) values of these products as shown in Tables XXVII and XXVIII. This is as expected since these products were stored under vacuum or nitrogen atmospheres in impermeable containers (hermetically sealed cans).

TABLE XXVII

Storage Stability Evaluation After 3 Months at 38°C - Phase I

Product		Moisture %	Water Activity (A_w)	Browning % Fluorescence	TBA	Microbial (TPC/gm)
Beef Rib Eye						
Treatment	1	44.0	.81	9.0	1.7	530
	2	33.3	.76	9.0	2.7	450
	3	20.8	.77	3.6	1.7	390
	4	16.9	.80	2.4	1.7	150
Ground Beef						
Treatment	1	43.1	.83	0.8	1.2	2200
	2	32.2	.78	1.0	1.2	60
	3	23.1	.77	1.3	1.3	60
	4	17.6	.80	2.2	2.2	50
Chicken White Meat						
Treatment	1	47.7	.80	4.3	1.6	240
	2	40.9	.79	4.6	1.2	240
	3	32.2	.79	5.6	1.4	100
	4	27.4	.84	6.8	1.0	30
Pork Tenderloin						
Treatment	1	47.2	.80	5.8	2.2	360
	2	38.4	.77	5.6	1.9	300
	3	31.7	.78	4.2	2.0	230
	4	22.4	.82	3.0	3.2	50
French Omelet						
Treatment	1	47.6	.81	2.1	1.2	220
	2	43.6	.81	2.2	1.4	360
	3	31.8	.80	3.1	1.8	Neg.
	4	23.2	.78	2.8	1.2	60
Carrots, Sliced						
Treatment	1	53.6	.82	1.1	-	Neg.
	2	51.2	.81	1.1	-	Neg.
	3	47.0	.82	1.9	-	Neg.
	4	35.9	.78	2.9	-	Neg.
Pineapple, Sliced						
Treatment	1	52.9	.80	1.1	-	Neg.
	2	49.8	.82	2.5	-	Neg.
	3	34.2	.77	6.0	-	Neg.
	4	31.7	.79	8.7	-	20

TABLE XXVIII

Storage Stability Evaluation After 3 Months at 38°C - Phase II

Product		Moisture %	Water Activity (A_w)	Browning % Fluorescence	TBA	Microbial (TPC/gm)
Turkey Dark Meat						
Treatment	1	46.9	.83	3	1.5	120
	2	40.2	.84	5	1.4	60
	3	30.4	.84	5	1.7	10
	4	20.8	.82	10	1.2	30
Halibut Fillet						
Treatment	1	53.3	.85	6	.4	910
	2	49.9	.84	5	.9	29,000
	3	41.4	.85	6	.4	1,500
	4	27.2	.83	5	.6	710
Ham						
Treatment	1	52.6	.83	1	.7	Neg.
	2	46.5	.83	3	.3	Neg.
	3	40.0	.83	3	.3	39,000
	4	33.4	.82	2	.1	2,700
Bologna						
Treatment	1	33.9	.85	3	1.6	Neg.
	2	30.1	.85	7	1.3	Neg.
	3	21.2	.85	12	1.2	Neg.
	4	10.9	.77	78	2.4	Neg.
Pancake						
Treatment	1	32.0	.85	17	1.1	4,600
	2	26.9	.83	33	1.7	310
	3	19.3	.78	36	1.9	220
	4	11.0	.65	29	2.5	160
Sweet Potato						
Treatment	1	53.7	.85	9	0	Neg.
	2	43.3	.82	15	0	Neg.
	3	37.9	.81	20	0	Neg.
	4	25.7	.83	34	0	Neg.
Peaches						
Treatment	1	60.5	.86	3	0	Neg.
	2	58.7	.85	2	0	Neg.
	3	37.9	.84	6	0	Neg.
	4	25.7	.85	10	0	Neg.

f) Microbial Counts - The microbial counts reported in Tables XXVII and XXVIII are considered to be within normal expected values for these products since no pasteurization process was used after treatment and aseptic handling techniques were not used in order to prevent microbial contamination during dicing, infusion, drying and packaging. These values are indicative that no significant microbial growth occurred during storage.

g) Acceptance Panel Evaluation - Panel evaluations of stored products are shown in Tables XXIX and XXX. Panel acceptance scores are all below the desired 6.0 average on a 9-point hedonic scale. The saltiness scores are as expected in most cases, being approximately a 2 using 1 as too low and 3 as too salty. Therefore, the low acceptance scores are not considered to be due to salt level.

In reviewing the panel comments regarding appearance, flavor and texture, it appears that flavor was the most critical in high internal solution level products while texture was most critical in low internal solution products. Flavor was apparently a result of high glycerol levels producing a bitter-sweet flavor which masked natural product flavors. This is supported by acceptance scores being equal to or higher for some treatment 2 product as found for treatment 1 product. In lower internal solution levels it was found that products became dry, tough and/or rubbery which severely lowered acceptance.

It appears from these data that most highly acceptable products would result from internal solution levels between 50% and 80% of normal water to solids ratios for most products. It is also apparent that a substitute for glycerol or some method of decreasing the sweetness of glycerol is needed in order to achieve highly acceptable products having internal solutions at the above level. In the case of products having internal solutions less than 50% of the normal water to solids ratio, some method of tenderizing or of softening the products is needed.

TABLE XXIX

Acceptance Panel Evaluation of Product
Stored 3 Months at 38°C - Phase I

Product	Acceptance Score[1]		Saltiness[2]
	Average	Range	
Beef Rib Eye			
Treatment 1	5.22	2-8	2.2
2	5.56	3-8	2.3
3	5.38	2-8	2.0
4	3.63	1-6	2.0
Ground Beef			
Treatment 1	5.43	2-8	2.1
2	5.43	2-8	1.9
3	4.36	1-7	2.0
4	2.68	1-5	2.0
Chicken White Meat			
Treatment 1	5.22	2-8	2.1
2	5.14	2-7	2.0
3	3.25	1-6	2.0
4	1.89	1-4	2.0
Pork Tenderloin			
Treatment 1	4.56	2-7	2.2
2	4.56	1-7	2.0
3	5.13	2-8	2.0
4	2.93	1-5	2.0
French Omelet			
Treatment 1	5.68	2-8	2.0
2	5.72	2-8	2.0
3	4.98	1-7	2.0
4	3.84	1-5	1.8
Carrots, Sliced			
Treatment 1	5.56	2-8	2.0
2	5.89	3-8	2.0
3	5.00	2-7	2.0
4	4.25	1-6	2.0
Pineapple, Sliced			
Treatment 1	5.57	2-8	2.3
2	6.14	3-8	2.0
3	4.88	1-7	1.9
4	4.75	1-7	1.8

1) Based on a 9-point hedonic scale.
2) Based on 1 = too low/3 = too salty.

TABLE XXX

Acceptance Panel Evaluation of Product
Stored 3 Months at 38°C - Phase II

Product	Acceptance Score[1]		Saltiness[2]
	Average	Range	
Turkey			
Treatment 1	5.37	2-8	2.3
2	5.62	2-8	2.2
3	3.79	1-7	2.4
4	3.23	1-6	2.0
Halibut			
Treatment 1	5.32	4-8	2.1
2	5.71	3-8	2.3
3	4.32	2-7	2.0
4	2.98	1-5	1.9
Ham			
Treatment 1	7.05	5-9	2.3
2	6.10	3-8	2.1
3	4.95	2-7	2.2
4	2.60	1-5	2.0
Bologna (on bread)			
Treatment 1	5.87	3-8	1.9
2	4.22	2-7	2.1
3	3.98	2-6	2.0
4	2.75	1-5	2.2
Pancake (with maple syrup)			
Treatment 1	6.75	4-8	1.9
2	5.41	3-8	2.0
3	3.22	1-6	2.1
4	2.90	1-5	2.0
Sweet Potato			
Treatment 1	5.89	4-8	2.0
2	4.95	3-8	2.1
3	4.45	2-7	1.9
4	3.70	1-6	2.1
Peaches			
Treatment 1	6.10	4-8	2.0
2	6.90	3-8	2.0
3	5.25	2-7	2.0
4	5.40	3-7	2.0

1) Based on a 9-point hedonic scale.
2) Based on 1 = too low/3 = too high.

XVI. Summary

The fourteen products specified under this contract, Rib-Eye of Beef, Ground Beef, Chicken White Meat, Pork Tenderloin, French Omelet, Sliced Carrots and Sliced Pineapple during Phase I and Turkey Dark Meat, Halibut Fillet, Ham, Bologna, Pancake, Sweet Potato and Peaches during Phase II, have been developed, prepared and tested, each at 4 different levels of internal solution as specified under this contract. The ratios of internal solutions to food solids specified were 100% ± 20% of water to solids ratio of the normal products, 50% of normal, 25% of normal and 10% of normal. Water activities of these products were adjusted to 0.70-0.86 (required 0.80-0.85) by incorporation of glycerol and salt and withdrawal of water. Glycerol and salt were introduced by equilibration with an external solution by soaking overnight under refrigeration for all products except French omelet, bologna and pancake. With these, glycerol was added directly to the formula prior to cooking. Drying of products so prepared was accomplished by use of vacuum at approximately 3 mm absolute pressure until predetermined amounts of water were removed. This was accomplished using chamber platen temperatures from ambient (22°C) to 38°C. Partially dried products were sealed under vacuum in metal cans for storage evaluation for 3 months at 38°C.

Evaluation of stored products showed that there was little, if any, loss of internal solution, no apparent oxidation of fats, some browning occurred but apparently not seriously detrimental to acceptability, no apparent moisture loss, no consequential changes in water activities and no significant microbial growth. Panel acceptance evaluation showed poor acceptance of all products with high internal solution level, with high internal solution products being criticized for sweet-bitter flavor while lower levels of internal solution products were found to be dry, tough, hard or rubbery. No excessive saltiness was observed for any of the products.

XVII. Recommendations for Further Investigation

If products were reconstituted to normal internal solution levels, it is believed that the three lower level products would approach normal acceptance values. This possibility appears feasible and warrants investigation.

It is apparent that some method of reducing sweetness in high level internal solution products and some method of decreasing toughness of low level internal solution products is needed. Further study regarding more thorough understanding of the effects of infusion on the insoluble fraction of the products is also needed. The effect of the product soluble solids and modification of their physical and chemical characteristics on their ability to chemically bind water would also be desirable in order to utilize natural product components to reduce water activity levels rather than adding so high a level of soluble materials such as glycerol.

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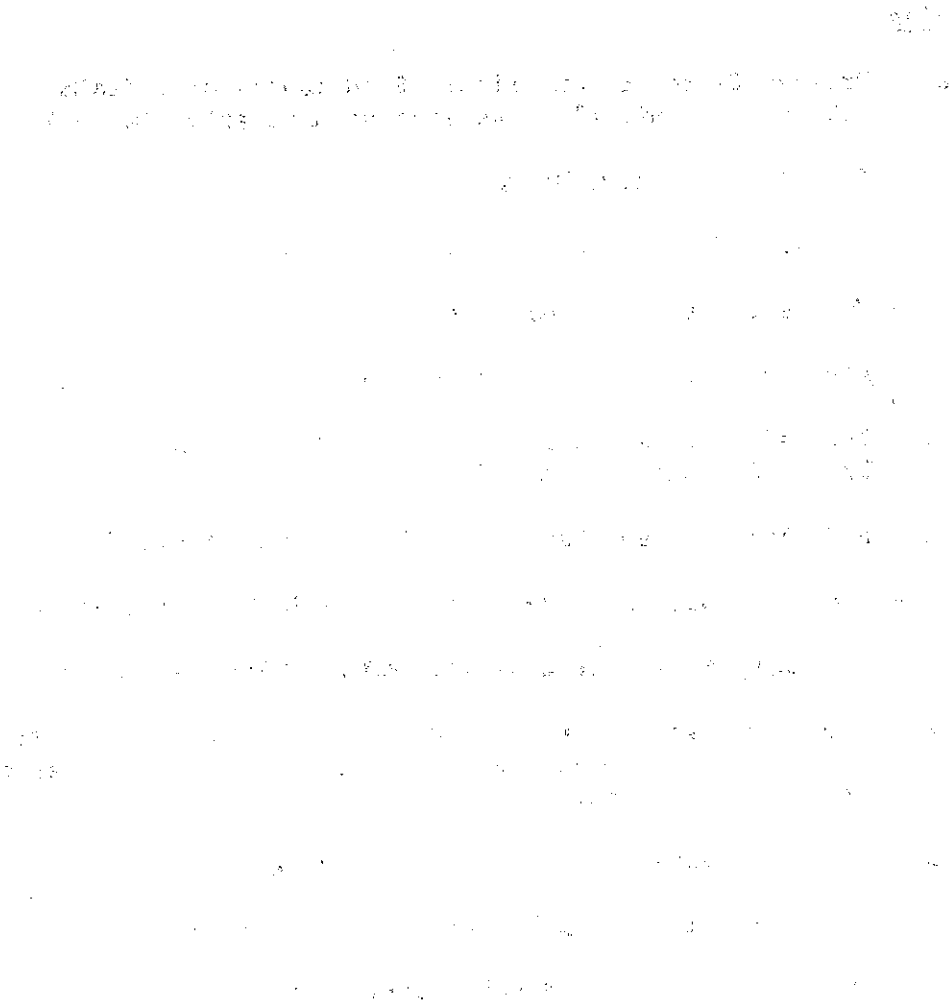

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13. ABSTRACT

Glycerol, salt and potassium sorbate were incorporated into 14 cooked food items, specifically diced beef, ground beef, chicken meat (white), pork tenderloin, turkey meat (dark), halibut, ham, sliced carrots, pineapple, peaches, sweet potatoes, omelet, bologna and pancake, in amounts to produce a water activity of 0.83 $\pm$ 0.02 after drying to prescribed levels of internal solution approximating 100, 50, 25 and 10% that of a conventionally prepared counterpart. Salt in an amount deemed normal to the specific item and glycerol in the amount needed to adjust water activity were incorporated into the formulas of the last 3 named products; the remaining items were equilibrated by soaking in an external solution containing salt and glycerol. Analytical measurements were performed on all products and appropriate controls for moisture, total and soluble solids, fat, water activity, density and expressable fluid. Intermediate moisture products were stored for 3 months at 38°C and subsequently tested for moisture content, expressable fluid, rancidity, browning, viable microorganisms and acceptability. Observations revealed acceptability as the primary area of difficulty. While most items received an acceptable score at the 100 and 50% drying level, many panel members recognized the off-flavor caused by the presence of glycerol. Drying to the 25 and 10% level generally elicited comments of poor texture and appearance from excessive drying.

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Development	8					
Preparation	8					
Solution (Aqueous)	10		6			
Internal Solution	10		6			
Beef	9		9			
Chicken	9		9			
Pork	9		9			
Fish	9		9			
Carrots	9		9			
Ham	9		9			
Pineapples	9		9			
Peaches	9		9			
Eggs	9		9			
Bologna	9		9			
Flours (Food)	9		9			
Intermediate Moisture Food	9		9		9	
Food Products	9		9		9	
Stabilization	4		7,4			
Acceptability	4		7,4			
Storage Stability	4		7,4			
Glycerol			6			
Salt			6			
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